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EDITED BY J. McKEEN CATTELL

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with comments by the publisher

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THE SCIENTIFIC MONTHLY

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SOME INTERESTING ANIMAL COMMUNITIES OF NORTHERN UTAH[1]

By Professor W. C. ALLEE
THE UNIVERSITY OF CHICAGO

A NUMBER of properly timed incidents determined the writing of this account. While the "Naturalists' Guide to the Americas" was in manuscript and the senior editor was urging all persons acquainted with areas worth describing to contribute short notes concerning them, the editorial office of this journal solicited an account of animal life that should be illustrated, interesting and not

[1] I am indebted to Dr. I. M. Hawley, Mr. Ralph King, Mr. Reed Christensen and Dr. Charles Rees, all formerly of the Utah Agricultural College at Logan, Utah, and to many others for assistance with field trips; to Mr. King and Mr. Christensen and Mr. David Hall, of Ohio State University, for access to their field notes; to Mr. Hall and to Mr. LaVell Cooley, of Logan, and others as acknowledged for photographs.

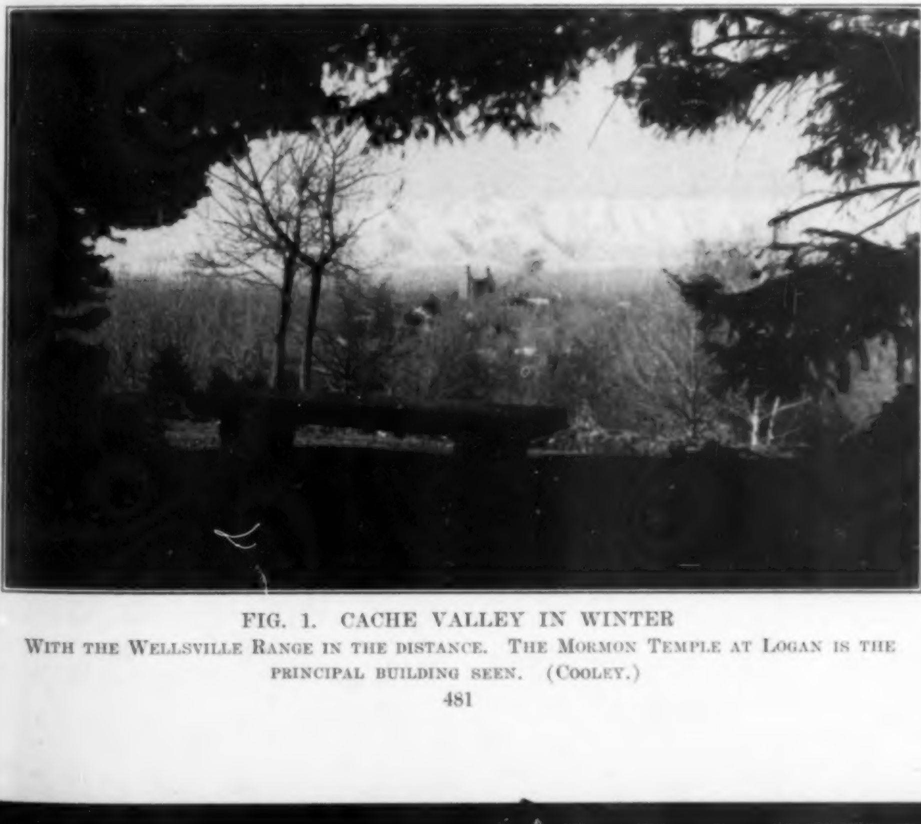

FIG. 1. CACHE VALLEY IN WINTER
WITH THE WELLSVILLE RANGE IN THE DISTANCE. THE MORMON TEMPLE AT LOGAN IS THE PRINCIPAL BUILDING SEEN. (COOLEY.)

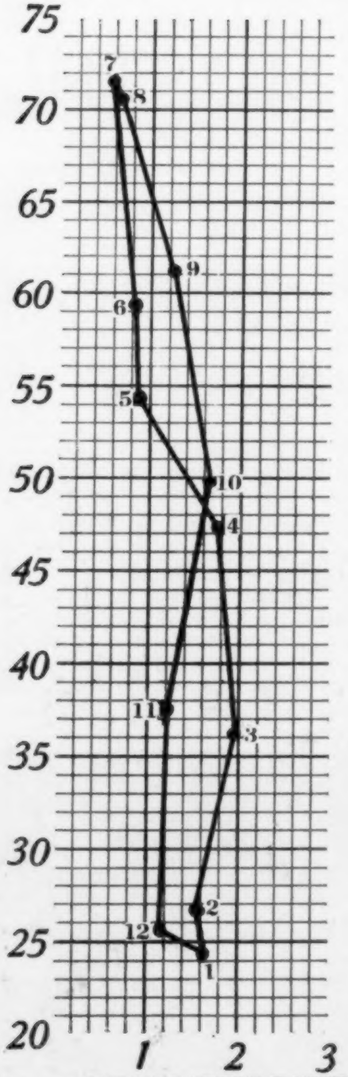

FIG. 2. A TEMPERATURE-RAINFALL CHART OF LOGAN, UTAH

BASED ON AVERAGES FOR THIRTY-ONE YEARS. THE ORDINATES GIVE MEAN MONTHLY TEMPERATURES IN FAHRENHEIT. THE ABSCISSAE GIVE MEAN MONTHLY RAINFALL IN INCHES. THE DATA ARE FROM U. S. CLIMATOLOGICAL DATA.

too technical. I had just spent two summers at my favorite relaxation of teaching zoology in a new region while exploring its zoological and scenic possibilities and had been supplied with numerous photographs by students and other friends. Finally zoological friends with vacations to plan, with or without automobiles, desired directions to interesting areas not too tourist worn and yet not too far from the beaten track of travel, where they might find some zoological stimulus as well as a western vacation.

Let all such, as soon as they can escape from classroom and laboratory, hurry west over the prairies and great plains while the June freshness still holds, if that be possible, cross the first ranges of the Rockies and turn north at Ogden either on train or the well-paved road. For headquarters they may well pass the cherry and peach orchards of Brigham City and, crossing the Wellsville Range, continue to the eastern side of Cache Valley where the flourishing city of Logan will furnish a civilized base from which a number of unique animal communities may be explored. While an automobile is a great aid in making the trips to be suggested, the ownership of a car is unnecessary.

The climate of the region may be understood from the accompanying graph of mean monthly rainfall and temperature given in Fig. 2, in which each month is numerically represented at the location which indicates the mean monthly temperature on the ordinates, and the mean monthly rainfall on the abscissae.

Cache Valley itself has been opened for trapping, exploration and settlement for a little more than a century. Despite the scanty rainfall, less than sixteen inches a year, and the great evaporation, seventy to eighty inches a year, the valley is well watered by rivers, irrigation ditches and artesian wells, so that the fertile plain, once the bed of old Lake Bonneville, is water-logged in places. Even among the cultivated fields the abundant yellow-headed blackbirds, sharing the swamps with their red-winged relatives, the long-billed curlews and an occasional egret, herons, hawks, ibises,

FIG. 3. LOOKING TOWARD MT. LOGAN
NOTE THE BEACH MARKS OF LAKE BONNEVILLE.

etc., remind one of the abundance of game and birds that must have greeted the early visitors to this valley.

The visiting naturalist soon learns that the distribution of these birds and of mammals is generally described in terms of Merriam's life zones which are locally recognized by the following trees which are used as "zone indicators":

Upper Sonoran:

a. *Lower-upper Sonoran*: Greasewood and sagebrush.

b. *Upper-upper Sonoran*: Nut pine, broad leaved cottonwood, cedar.

Transition: Narrow-leafed cottonwood, oak.

Canadian: White fir, blue spruce, aspen, Douglas fir.

Hudsonian: Engelmann spruce, sub-alpine fir.

Tundra: Bearberry.

If he remembers his zoogeography, the visitor will know that the life zones of Merriam were originally supposed to be plotted on a temperature basis; but since the exact yearly temperature ranges are hard come by in the field, these so-called zone indicators have been substituted, often without careful physiological work to determine the temperature relations of the indicators themselves.

When one starts to climb Mt. Logan (Fig. 3) by the excellent trail past the "Girls' Camp," (with these local zone indicators well in mind) he finds that the life zones are not the same on the two sides of the mountain. On the valley side facing west the sage brush, indicating "Lower-upper Sonoran," extended from the valley floor at 4,500 feet above sea level to the top at 9,713 feet, while on the eastern face this is soon superseded by the "Transition." The "Transition Zone" here is very narrow and is limited to the region near the stream which makes one question to what extent it is a temperature phenomenon. It soon gives way to the dense stands of Douglas fir and the beautiful aspen woods of the "Canadian Zone" (Fig. 4). One climbs through these and on through the Engelmann's spruce and the sub-alpine fir of the "Hudsonian Zone" only to come out above edaphic timber line into a good sage-brush association, indicating "Lower-upper Sonoran" when Alpine tundra was expected!

Obviously something has gone wrong with the indicators. The temperature relations here, almost ten thousand feet above sea level, are decidedly different from those of the valley, as is shown by the mid-summer snow banks and the spring beauties and other vernal flowers blooming here long after they are past in the valley. The critically minded field naturalist with ecological training is likely to wonder if it would not be more scientific to describe these regions as sagebrush, aspen or Engelmann's spruce associations rather than to generalize them into the so-called life zones with their implied relationships between these mountain belts and the latitudinal belts of the eastern part of the continent.

FIG. 4. THE ASPEN WOODS OF THE "CANADIAN LIFE ZONE"

FIG. 5. "THE HUDSONIAN LIFE ZONE"
NOTE THE LIGHT SAGE BRUSH AREAS INDICATING "LOWER-UPPER SONORAN" ON THE PEAK ABOVE.

FIG. 6. LOOKING SOUTHEAST FROM DYKE. BEAR RIVER BAY. (COOLEY.)

FIG. 7. SNOWY EGRET

APPROXIMATELY THREE WEEKS OLD, JULY 3, 1925, BEAR RIVER BAY. (HALL.)

Further, one can but marvel at the potency of an idea in diverting attention from apparent facts when he considers the obvious correlation between moisture and plant and animal distribution in this region and the decidedly less obvious temperature relations. Yet the latter was chosen as the original basis of the life zone concept.

A number of mountain tops are available in easy trips from Logan as a center: as, Mt. Logan; Gog, Magog and Naomi; Ben Lomond and the Wellsville Range. None of these carries one above true timberline, since this would be found only at an elevation of 11,000 to 12,000 feet. These trips will take one into a wealth of broken mountainous country populated with elk, bear, porcupines, ground squirrels and the like. The game preserves include some 268,000 acres of the Cache National Forest.

Very occasionally on such climbs one finds small mountain ponds or lakes a hundred yards or so in diameter, at a height of 8,000 to 9,000 feet. These are populated in midsummer by a shrimp, *Branchinecta;* and by salamanders, *Ambystoma tigrinum,* adults and larvae; and by the toad *Bufo boreas.* In lower-lying ponds the apus-like *Lepidurus couesii* may be found in abundance.

Bear River Bay may readily be reached from the base camp at Logan by a few hours' automobile ride, providing arrangements have been made with one of the gun clubs or through the Brigham City Chamber of Commerce.

These extensive flats (Fig. 6), covering many thousands of acres, are largely held by private gun clubs. The caretaker of the Bear River Club, Mr. V. F. Davis, is an invaluable aid to the newcomer in this area. The flats are well known to sportsmen and have been the subject, recently, of a series of papers by Dr. Alexander Wetmore concerning the bird life with special reference to the duck sickness, which will be mentioned later. The region is much less known to teaching zoologists and to laboratory workers.

Bear River is the largest of three streams entering Great Salt Lake. It arises in Wyoming, drains into and out of Bear Lake (whose level is now artificially controlled), flows through Cache Valley and then through a narrow gorge into the Salt Lake Valley, at the outer edge of which, after forming an extensive delta, it breaks up into a number of branches before entering Bear River Bay of the Great Salt Lake. This is one of the great nesting and collecting grounds for western birds.

Arrangement can be made for staying at one of the numerous gun clubs and for transportation by suitable flat-bottomed boats. The visitor should be one of a very small party and should be prepared thoroughly for a demonstration of the abundance of mosquitoes as well as of ducks, ibises, herons and other birds.

According to Wetmore, eleven species of ducks and the Canada goose nest

FIG. 8. YOUNG AMERICAN BITTERN
BEAR RIVER BAY. (COOLEY.)

here. He estimates that some 15,000 ducklings come to maturity on these marshes each season. Other nesting birds are also abundant. Bitterns, great blue herons, egrets and snowy herons, black-crowned night herons, coots, Wilson's phalarope, avocets, black-necked stilts, sandpipers, willets, long-billed curlews, short-eared owls, marsh hawks, yellow-headed and redwing blackbirds, meadow larks and marsh wrens make their nests here, to mention only some of the more prominent. Finding nests is not arduous. The greater difficulty is to avoid stepping on eggs or on the nestlings while tramping through the short marsh grass or breaking through the canes.

Important as these flats are for nesting, they are equally important for molting, feeding and refuge grounds. The male ducks of most species nesting in this region do not stay with the female and the young (Wetmore says the ruddy drake is an exception) but soon gather in large flocks, coming from many other regions as well as from the local nesting grounds. On June 20, 1925, male pintail ducks had gathered near the opening of the south fork of Bear River so that the frightened flock which flew directly over us literally darkened the sky, as my father says wild pigeons in Indiana once did. In 1916 Wetmore found 130 pairs of breeding pintails on these marshes and as early as June 14 he records a flock of from 2,500 to 3,000 males having collected. Later in the season when shooting begins, even in recent years, shoveller

FIG. 9. MARSH HAWK'S NEST, EGG AND YOUNG
BEAR RIVER LOWLANDS ABOVE BEAR RIVER BAY. (COOLEY.)

ducks have been seen on the lake nearby in a bank two miles long and a quarter of a mile wide, busily feeding on the brine shrimp (*Artemia fertilis*) and on the larvae of pupa of the salt marsh fly, Ephydra.

One can not tramp these marshes near the close of the nesting season without being impressed with the prodigality of nature and with the loose adaptation of many animals to their environment. The thousands of birds in the air and on the ground must mean that the species are locally very successful; and this is indeed one of the great nesting marshes relatively untouched as yet by man during the nesting season, yet everywhere one sees dead nestlings, broken eggs, nests that have been flooded, others apparently deserted with only a partial clutch of eggs. The infant avian mortality is appalling and provides a great though wasted opportunity for avian social work!

An unexpected correlation between man's activities and the welfare of wild life has come to light in these marshes. For many years ducks have been found sick or dead in some numbers, but when the size of the colonies here was considered, these were not thought to be of great importance. However, in 1910 and the years following, the sickness became so widespread that the assistance of the United States Department of Agriculture was called in, and Dr. Alexander Wetmore spent three seasons in field studies with headquarters on these Bear River Flats. The seriousness of the disease and something of the abundance of the bird life of these marshes can be seen from the fact that Mr. V. F. Davis supervised the collection and burial of 46,723 dead ducks between September 7 and September 23, 1913. These were taken only from the open and Mr. Wetmore estimates that they represent only about 20 per cent. of the dead ducks on the flats. In other words, some 230,000 ducks died there in that one autumn from this illness.

Observations and experiments showed the illness may be caused by the chlorides of calcium and magnesium present on the alkali flats. That the disease did not appear as a plague earlier is to be explained from the rapid increase in land under irrigation, so that recently the stream flow has been markedly decreased during midsummer months. In fact, from July to September very little water flows out the mouths of the rivers entering Great Salt Lake, except from lower tributaries and from irrigation seepage. On these flats, frequently but an inch or two above water level, the alkali collects at the surface as the soil dries. The wind may drive water over these low-lying flats where it may take up the troublesome salts (along with NaCl). Such driven water would also carry a supply of seeds and bugs upon which birds might feed, taking water with the food and so obtain the necessary dosage of alkali salts. Rains would similarly form puddles containing the alkali salts. The subsoil here is strongly alkaline and there are plenty of the lethal salts available if a flow of fresh water is stopped.

When the height of irrigation ceases in the autumn, the illness tends to diminish rapidly with the new supply of fresh water. Dr. Wetmore found that the ailing birds will recover if placed where they can secure fresh water.

Apparently, by his industry in placing more and more land under irrigation, man is jeopardizing the life of this horde of wild fowl, since not only the ducks, but some twenty-five other species of Bear River birds are known to suffer from the malady. This is happening without industrial contamination or the physical destruction of the breeding grounds.

FIG. 10. BLUE HERON COLONY
BEAR RIVER BAY. (COOLEY.)

Many local observers do not accept Dr. Wetmore's explanation. They object that, with irrigation demands continuing to increase, the duck sickness should also increase yearly, which it is not doing. This may be explained in a number of ways. It may be that a partial temporary immunity has been gained by the great epidemic of ten to fifteen years ago; or that the birds have become acclimated to the new conditions in an average season; or the reported, but questioned, freshening of the water of Bear River following the completion of the Lucin Cut-off of the Southern Pacific Railway may have a saving effect.

Lead poisoning from eating the stray pellets of lead left after the shooting also causes sickness and death of many waterfowl. The pellets remain on the marsh for years and can readily be recovered from silt near the shooting blinds. Six No. 6 shot pellets experimentally fed to ducks were always fatal, and one might be.

At the Bear River Bay marshes one comes in contact with the brackish waters of Great Salt Lake—now well upon the marshes, and again only out at the mouths of the channels, depending upon the season and the strength and steadiness of the wind. Closer contact with the animal life of the lake may well be deferred until arrangements have been made to visit Hat Island, the nesting ground in mid-lake of gulls, great blue heron and white pelicans. Such arrangements may be made for a consideration with the Southern Pacific Railroad. A party of fifteen or more

are able to make the trip very reasonably and within a day's time. The through train stops at Colin in mid-lake on the Lucin Cut-off, and a Southern Pacific Railway launch will carry a party twelve miles south to Hat Island. The island is approximately twenty-one acres in extent and rises in the center of Salt Lake about seventy-five feet above lake level. The underlying rock is of Pre-cambrian glaciated schist, containing granite boulders, as can be seen in Fig. 11.

On the cut-off trestle and about the boats are a large number of spiders, which obviously feed on the swarms of Ephydra, or brine fly, whose abundance as imagos on the surface and near the water have been described by Aldrich. Despite this description one needs to watch the motor boat plough through the heavy brine, stirring up the brown mass from the surface, and see this mass break into myriads of small brown flies that get into nostrils and mouth in spite of every care, to realize how thick flies can be.

Tow nets or dip nets towed overboard through the brine bring in numbers of the Ephydra larvae (three species have been described) and pupa in their cases, along with the brine shrimp, *Artemia fertilis* Ver., which is found in numbers all along from the trestle during the two hours' run to the island. One of the Corixidae is also found in the lake, but less abundantly. Vorhies also lists a number of Protozoa, including Amoeba. Through the clear water a greenish growth could be seen. F. P. Daniels summarizes the plants reported in 1917. He found two species of Chlamydomonas, two diatoms and one of blue-green algae (*Aphanothica packardii*) in the region near Salt Lake City. The last occurs in considerable masses.

Dr. V. E. Shelford reports the hydrogen-ion concentration of Salt Lake at Salt Air to be pH 8.1. My own determinations in mid-lake show uncorrected

FIG. 11. GULLS ON THE PRECAMBRIAN GLACIATED SCHIST OF HAT ISLAND. (COOLEY.)

FIG. 12. CALIFORNIA GULLS AT HAT ISLAND. (TANNER.)

readings with phenol red of pH 8.3. Just what the salt error may be, I do not know. The brine is 23 per cent. salt.

The swarms of gulls—nestlings, yearlings and full-plumaged—found on and near the island are well worth the visit (Figs. 11–12). Any doubts of the ability and willingness of the gulls to get salt water in their mouths last only until one throws a test bread crust overboard. Regurgitations of *Ephydra* cases on the island show that the larvae and pupa of the brine fly are used as food. Doubtless the abundant brine shrimps are also eaten.

In addition to the gulls we found young of the white pelicans and nests of the great blue herons on the island. Palmer (1915), visiting the island in mid-May, about two months before the time of our visit, found both California and ringed billed gulls to the number of about 15,000 to 20,000, about 2,000 of the white pelicans, about 400 great blue herons, a small colony of Caspian terns and one killdeer, apparently a chance visitor. Our estimates ran much higher for the gulls and about the same for the pelicans.[2]

The great low-lying nests of the great blue herons (Fig. 14) attract the attention of the easterner, who has been used to see such nests only at the top of tall trees. The twigs with which they are made have been carried for the most part from the mainland just as the food of the nesting birds also comes mainly from the swamps, lakes, rivers and fields of the mainland. The young pelicans are easily rounded up into close droves (Fig. 15). Many of them when excited

[2] Dr. Charles G. Plummer, of Salt Lake City, has made extensive studies of the birds on Hat Island which are not yet in print unfortunately.

FIG. 13. GULLS NEAR HAT ISLAND. (TANNER.)

regurgitate their food, and on examination of one bird's dinner deposited at my feet I found this story could be reconstructed.

Early in the morning of July 5, 1924, a young small-mouthed black bass was feeding in the fresh waters of one of the mainland streams and had half swallowed a smaller minnow. His rush after food brought him within range of a feeding pelican and he was gobbled down along with his half-swallowed prey. When several more fishes had joined this one, the pelican, probably in company with a small group of others, rose clumsily from the water and made its way in V-formation back to the nesting grounds on Hat Island. There a young pelican persuaded this particular bird to allow it to feed from the fish which had been completely swallowed and the bass with its half-swallowed minnow were transferred from the stomach of one pelican to another. Later, when we came on the island, the youngster in his excitement presented the slightly digested fishes to us and, as we turned away after a careful examination, the greedy gulls were again gobbling the much-swallowed fish. I can not be sure that this was its last esophageal journey, for the young gulls were also regurgitating in their excitement at our approach, and this bass with its half-swallowed prey may well have come up and down once more before falling to pieces.

In addition to the birds we found the following animals on the island: dragonflies, Libellulidae; ground beetles, Carabidae; flies, Muscidae, Ephydra; Dermestid beetles (two species, adult and larvae); Circulionid beetles; spiders, Dysideridae; wasps, Specidae; the western harvester ant, *Pogonomyrmex occidentalis;* Geometrid moth larvae, and the lizard called the desert race runner (*Cnemidophorus tessellatus tessellatus*). In addition there were a number of biting bird lice, one colony of which was found almost completely lining the pouch and gullet of one of the young pelicans. It is interesting to note that Palmer in 1915 records seeing one species of lizard on the island.

The region near Great Salt Lake is shown on even the more conservative maps as desert country, but green fields, great swamps and a sagebrush-covered island all crowded with animal life do not fit the usual picture of desert life. True desert conditions are nearby. One finds that the western part of Promontory Ridge, which looks down on the teeming Bear River Bay marshes, has only ten inches of rain or less per year. One of the characteristics of life of the region is the sudden transition from one animal habitat to another.

In order to reach the Salt Lake Desert region, which has less than five inches of rain a year, one should travel by automobile or train through Salt Lake City to Knolls, about eighty miles west of Great Salt Lake on the transcontinental automobile road, which we shall hope is now improved out of the axle-deep ruts filled with fine dust that characterized it a year ago. Here are two types of desert: the lifeless alkali flats, and the adjoining sand dunes where life is more abundant.

FIG. 15. THE ROUND UP OF YOUNG WHITE PELICAN.

FIG. 14. BLUE HERON'S NEST ON HAT ISLAND.

There a brief search gave us the western harvester ant; two dragon flies, Libellula and Epiaeschna; numerous Lycosid spiders; robber flies, Asilidae; adult ant lions, Myrmeleon; darkling beetles, burrowing in the sand; solitary wasps, Specidae; tiger beetles, Cincindellidae; four species of grasshoppers; one praying mantis; two lizards, the desert race runner (*Cnemidophorus tessellatus tessellatus*) and the sage swift (*Sceloporus graciosus*); the coyote and a species of Lepus.

Other interesting animal communities available from headquarters near Logan include those of Bear Lake, a beautiful mountain lake some seventeen miles long and eight miles wide, about 6,000 feet above sea level, with an extensive swamp at the north end, and with a small hot

water spring nearby. There is the extensive Logan Cave on the route to Bear Lake. In Idaho, within a day's run by automobile, one may find lava beds at the "Craters of the Moon." One may find planarian watercress swamps, small alkali flats, extensive areas waterlogged from irrigation, together with the expected mountain brooks with their excellent supply of stocked trout and associated animals.

The problems arising from a consideration of the animal communities of the region are numberless. The obvious economic ones are being attacked, but many of the underlying biological problems are untouched as yet. There is a vast need of studies in taxonomy, particularly among the insect groups. A great many of the specimens collected are new species or new varieties. Thus Dr. Annette Braun collected microlepidoptera in this region for six weeks in 1924 and obtained thirty-six new species and one new genus out of one hundred and fourteen species on which she reports. It seems a pity that the interest has shifted so far from taxonomy that much of this basic work remains untouched in the western country. When species are unknown, it is obvious that the ecological relations of many species are unsuspected. In a region offering such sharp lines of demarcation between different animal communities one has an unusual opportunity for profitable study of the operation of environmental factors in limiting distribution. Topographic, climatic and soilic transitions are sudden and extreme. Such analyses obviously call for modern instrumental studies as well as the older and always necessary studies of biological relations.

It is important to record that the rural and city population of the region are unusually interested in the results of biological investigations and are sympathetic and ready to be helpful in furthering such work. This is in part due to their recognition of the dependence of the agriculture and mining of the region upon scientific aid.

With a fairly extensive field experience with different types of animal habitats, I know of no other region possessing so great a variety of animal communities within so short a range, and I have never seen in nature such a demonstration of the primeval abundance of animal life on land. The fact that nearby there may be an almost absolute dearth of animals only makes the abundance more dramatic. The availability of this region for an interesting summer excursion for biologists is by no means lessened by its proximity to the Jackson Hole country and Yellowstone National Park on the north and to the spectacular Cedar Breaks and Bryce's Canyon region to the south.

THE RIDDLE OF LIFE

By Professor J. E. GREAVES
AGRICULTURAL COLLEGE, LOGAN, UTAH

THERE are probably few individuals who have lived to the age of understanding without asking at least themselves the questions: What is life? From whence does it come, and how does the living differ from the lifeless? These have been riddles of the centuries. The philosophers have pondered over them. The scientists have taken to their laboratories in an endeavor to wring from nature an answer. From the very dawn of history we find that all mankind has concerned itself with these momentous questions, and to-day some will say that they are no nearer solved than when primitive man strolled from his cave, club in hand, to slay the living that by so doing he might live. Be this as it may, contrary to the belief of many, the search has yielded a harvest rich indeed. It is the history of this harvest and some of its fruits which we wish to examine briefly.

The race is like the child in that during the early stages of development the imagination is the predominating instinct; hence we find the first descriptions of the origin of life highly imaginative. The ancient Greeks looked on the Goddess Gea as the mother of mankind. In their glorious mythology they pictured men and women as springing into life from the stones cast on the earth. The Celts pictured the soil as peopled with gnomes and pixies, friends or foes of mankind. Many ancient writers fancifully portrayed the transformation of dead into living matter. The Greek philosophers taught it. Aristotle wrote in 384 B.C.: "Animals sometimes arise in soil, in plants or in other animals."

Three centuries later Ovid, in his dissertation on the Pythagorean philosophy, defends the doctrine of spontaneous generation, whereas Virgil in his Georgics gives directions for the artificial production of bees.

Paracelsus (1492–1541), a Swiss medical philosopher who greatly confused fact and fancy, gives instructions for the making of Homunculus. Certain substances are to be placed in a bottle; the bottle is well stoppered and burned in a manure heap. Every day certain incantations are pronounced over the bottle. In time, so Paracelsus declares, a small living human being (homunculus) will appear in the bottle. He naïvely admits that he never succeeded in keeping the little man alive after it was taken from the bottle. Kircher went a step farther and describes and even pictures certain animals which he claims were spontaneously produced before his very eyes, through the action of water on fragments of plants.

During the middle of the sixteenth century Cardano thought that water gave rise to fish and other animals and that water was the cause of fermentation. An Italian, Bononani, tells of a wonderful transformation which he claims to have witnessed. Rotten timber which he rescued from the sea produced worms; these gave rise to butterflies; and strangest of all the butterflies became birds and flew away. Gradually these grotesque fanciful opinions concerning the origin of life were abandoned, and it was believed that only the lower plants and animals, seaweeds, algae, lichens, lice, mites and maggots could develop spontaneously. Even to-day we find

fairly intelligent individuals who believe that mites and lice can develop without parents and that the hair from the tail or mane of a horse will change into a worm or snake if placed in water and exposed to light and warmth.

Every one took it as a self-evident fact that maggots originated spontaneously from decomposing meat or cheese, until an Italian poet and physician, Redi (1626–98), took the simple precaution of screening the mouth of jars containing meat so that flies could not enter. They were attracted by the odor and deposited their eggs on the gauze, and it was from these that the so-called "worms" arose.

By the middle of the seventeenth century the theory of the spontaneous generation of mice, scorpions and maggots had been proven untenable. But at this time Leeuwenhoek discovered various living moving animalcules in raindrops, saliva and many putrefying substances.

Then all were sure there had been discovered the origin of life. For any one provided with this new instrument, the microscope, could easily demonstrate for himself the spontaneous generation of microscopic eels in vinegar or produce myriads of different and interesting creatures in simple infusions of hay or other organic material.

Needham, a Catholic priest, in 1745 placed decaying organic matter in a closed vessel. This he placed on hot ashes to destroy any existing life. On examining the contents of the vessel after a time, he found micro-organisms which were not there in the beginning. From this he evolved his theory that a force called "productive" or "vegetative" existed which was responsible for the formation of organized beings. The great naturalist, Buffon, elaborated the theory that there were certain unchangeable parts common to all living creatures. After death these ultimate constituents were supposed to be set free and become active until with one another and still other particles they gave rise to swarms of microscopic living creatures.

In 1769 Spallanzani repeated the work of Needham. He boiled the material for one hour and kept it in hermetically sealed flasks. He wrote: "I used hermetically sealed vessels. I kept them for one hour in boiling water, and after opening and examining their contents, after a reasonable interval, I found not the slightest trace of animalcules, though I had examined the infusion from nineteen different vessels."

But the believers in the theory of spontaneous generation were not convinced, as they claimed that the boiling had altered the character of the infusion so it was unfit for the production of life. Voltaire, with his characteristic satire, took up the fight at this point and ridiculed the operations of the English clergy "who had engendered eels in the gravy of boiled mutton" and wittily remarked: "It is strange that men should deny a creator and yet attribute to themselves the power of creating eels." This, however, was a controversy to be settled not by ridicule but by experimental evidence.

Spallanzani answered their objections by cracking one of the flasks. Air entered and decay immediately set in. Even this was not sufficient to overthrow an age-long belief. The abiogenist argued that "the sealing of the flask excluded air and the oxygen of air is essential for the generation of life."

This objection was answered by the work of many an ingenious investigator. Schulze in 1836 passed air through strong acids and then into boiled infusions and failed to find life even after the infusion had stood some time. Schwann passed the air through highly heated tubes with the same results. To this the argument of the opponents was, "heat and chemicals so alter the physical and chemical composition of the air

that it is unable to engender life." The work of Shroeder and Dusch (1853) was more convincing, for they found that it is sufficient to stopper bottles containing heated milk, meat and other perishable substances and they will keep indefinitely.

Even this was not sufficient to overthrow the belief in spontaneous generation, for as late as 1859 Panchet revived it in a book in which he heaped experiment upon experiment and argument upon argument spiced with the logic and sarcasm of the man of science in favor of spontaneous generation. He was opposed by Pasteur, who collected the floating particles of the air surrounding his laboratory in the Rue d'Ulm and subjected them to microscopic examination. He sowed them in sterilized infusions and obtained abundant crops of microscopic organisms. He showed that the cause which communicated life to the infusion was not uniformally diffused, but in the workshop and crowded streets of Paris living organisms were numerous, whereas on the tops of high mountains and glaciers the air is usually free from life. He showed that beef tea sterilized in flasks with the neck bent like that of a swan did not spoil, even though exposed to the atmosphere. As late as 1922 there was exhibited in the United States one of those flasks of beef tea which it was claimed Pasteur had prepared over fifty years before; it was still clear and free from life.

In the spring of 1864 nearly all Paris was at one of Pasteur's lectures in which he portrayed vividly and with a touch of scorn for his adversaries his conclusion concerning the origin of bacteria. He said: "There is no condition known to-day in which you can affirm that microscopic beings come into the world without germs, without parents like themselves. They who allege it have been the sport of illusions, of ill-made experiments, vitiated by errors which they have not been able to perceive, and have not known how to avoid." Then in a passage of singular beauty he described himself watching and imploring his flasks to give him a sign of life, but they would not, "for I have kept from them, and am still keeping from them that one thing which is above the power of man to make; I have kept from them the germs which float in the air; I have kept from them life."

Thus was established the principle that life springs only from life, from the viewpoint of the welfare of the human race the most momentous discovery made by man, for on it is reared those three sciences which have done so much to prevent, alleviate and cure human ills—bacteriology, pathology and surgery.

To-day we can only speculate as to the origin of life on this planet. The most outstanding theories can be summarized as follows:

Vitalism had its champions for ages and reached the heyday of its power in the eighteenth century. It assumes that an all-controlling, unknown and unknowable mystical and permechanical force was responsible for all living processes. Such a postulate carries the subject beyond the realm of scientific investigation and as here laid down is not generally held by the thinkers of to-day.

All experiments performed by man and those occurring naturally and studied by man invariably point to the conclusion that life always springs from life. This has caused many serious thinkers to ask, "Is not life as old as matter itself and is carried from planet to planet?" Some bacterial forms will lie dormant for years and stand temperatures as low as 250 degrees C. Hence Arrhenius suggests that life is driven from planet to planet by light waves, and finds lodgment and grows wherever conditions are appropriate. Such a

hypothesis removes the question from this to some other sphere beyond the reach of man and does not satisfy the inquisitive mind; hence various other theories have been formulated which try to account for its formation on this earth. In all these it is assumed that the various changes occurring in the cooling and reacting earth gave rise to molecules endowed with life. All are ingenuous but speculative and loudly proclaim the need of a future Darwin with a mind great enough to sweep the whole universe and formulate for mankind a fruitful working hypothesis. In the meantime, man accepts the dictum that life springs only from life and divided the objects on the earth into the two great classes—the living and the lifeless. The former possess certain characteristics which are not possessed by the latter. These properties are movement, growth, reproduction, respiration and irritability. It is to a study of these that the scientist has turned his attention during the last quarter of a century.

Lifeless matter often manifests movement. A rock, cut from the side of a mountain, rolls into the valley below. Movement is due to position. The migration of the amoeba may be closely imitated with a drop of chloroform placed in water on a superficially hardened shellac surface. A marked surface tension develops between the chloroform, the water and the moist shellac layer; soon the chloroform and shellac commence to be moistened at some point, and at this point the surface tension of the chloroform is lowered and it seeks to spread itself out. By various modifications of this method one can imitate the chasing of small amoebae by larger ones, the taking up of food and very many interesting life phenomena. In all these imitations, however, it is to be noted that the impelling factor comes from without, whereas in the living cell it comes from within. This may manifest itself as the change of position on the earth's surface, as in the case of the animal or the internal protoplasmatic movements of the plant cells. While much of this may be due to osmotic changes of the protoplasm, yet the energy comes from the food, and in this the law of conservation of energy has been found to rigidly hold. From it we are learning that the efficient engines for the transformation of energy are not man-made but the natural living cells. And although in this respect the body of man is wonderful, yet the little firefly we observe darting about on a dark summer evening is probably the most efficient dynamo in existence.

Growth, yes, lifeless material grows, as even the young boy understands as he rolls his snowman. A lump of copper sulfate thrown into a dilute solution of potassium ferrocyanid soon develops a brown envelope which throws out upward-growing runners, and in half an hour's time the fluid is filled with figures which vividly recall both the shape and color of the seaweed. The weight of the resulting artificial plants may be 150 times that of the original copper sulphate. We all know that a crystal placed in the mother liquid grows. This has been likened unto the growth of the living organism, but only a moment's thought is necessary to show that the likeness is only superficial. Crystals grow by the addition of a like material, whereas the living cell takes dissimilar substances and transforms them into another material: living tissue.

Inasmuch as growth viewed from the physiological viewpoint consists of the transforming of unorganized foodstuffs into new chemical entities which constitute the organized protoplasm of the animal, it is evident that the living organism must have food. It is but a short time since the rule was that the food of man should contain carbohydrates, fats, proteins and water. Ash was looked upon more as an impurity which was

tolerated but not essential until it was found that an animal on such a diet died sooner than another receiving only water. Ash then was found essential not alone as building material but as a regulator of body processes, and some even claim that life phenomena function even more through the mineral elements than through the organic. To-day we know that a diet consisting of carbohydrates, fats, proteins, ash and water will not maintain growth unless the growth-promoting Vitamine B is present, and even then for only a short time unless the regulatory Vitamins A, C and D are also included in the diet. Nor is the kind of protein without significance. The growth-promoting lysine and the regulatory tryptophane must be contained within their molecule.

The diet may meet all these requirements and still there be no growth even in the young animal, or when there is growth it may be abnormal, as in the case of gigantism, acromegaly and myxedema, when there is an abnormal functioning of the endocrine organs. The results which have been obtained in transforming the cretin into a normal individual is a metamorphosis as wonderful as the transforming of the tadpole into the frog. Gudermasch made the remarkable discovery that even this metamorphosis, which in our climate usually occurs during the third or fourth month of life of the tadpole, can be brought about at will even in the youngest tadpoles by feeding them with thyroid gland—no matter from what animal. By feeding very young tadpoles with this substance frogs no larger than a fly can be produced. Allen added the observation that if a young tadpole is deprived of its thyroid gland it is unable ever to become a frog and it remains a tadpole, which, however, can reach a long life and continue to grow beyond the usual size of the tadpole. However, when such abnormal tadpoles are fed with thyroid they promptly undergo metamorphosis. Similarly, the products of the endocrine organs govern the nature and rate of growth.

The size which the individual reaches is not alone determined by inheritance and the food received but also by the activity of the pituitary gland. For today in animal experiments there is produced at will the giant or the pigmy by the use of tethelin. These discoveries have placed in the hands of the dietitian and physician weapons against abnormalities of growth in stature and in mind which in the age of mythology were attributed only to the gods.

In man there are periods of rapid growth followed by quiescent periods. These are three in number, each beginning with a period of relatively slow growth, followed by a period of very rapid growth and culminating with the termination of the cycle in a period of slackening growth again. In the case of the first two cycles this slackening of growth is followed by a fresh spurt of acceleration due to the succeeding cycle. The first cycle closes toward the end of the first year, the second about the sixth year and the third at maturity. It has been recently shown by Robertson that these cycles of growth obey the equation of an autocatalyzed monomolecular reaction.

The third characteristic of the living, and the only property it is certain that some of the simpler organisms possesses—organisms too small to be seen with even the most powerful microscope—is that of reproduction.

Although the morphological changes occurring in multiplication have long been studied, it is only recently that successful attempts have been made to study that first stage of reproduction—fertilization. The work of Loeb on the egg of the sea urchin or frog has demonstrated that they may be successfully fertilized by treating first with a dilute solution of

butyric acid and then with hypertonic sea water. When thus treated the unfertilized egg develops into the adult possessing maternal characteristics. This called forth from the laity the statement that life had been created, but the answer from the scientist came, "No, life has not been created. There has only been arrested a chemical process which has its origin with the origin of the cell and which ultimately ends in the death of the organism." To test this proposition the unfertilized cell was treated with antiseptic strong enough to retard enzymic action but not strong enough to kill the cell, and even the unfertilized cell developed for some time. Moreover, Loeb found that the duration of life, barring accidents and disease, in the metazoa, is inversely proportional to the temperature at which that animal is living. Decrease the temperature ten degrees and one doubles or trebles the length of life. Or, in other words, living matter within certain limits obeys the temperature law of van't Hoff and Arrhenius.

If certain salt-water fish be placed in a solution of common salt having the same osmotic pressure as has sea water the fish soon die. Death in this case is not due to a lack of food, as a similar fish placed in distilled water lives for some time. Now, if a small quantity of calcium chlorid had been added to the first solution the fish would have lived. Moreover, if the heart be removed from the body of an animal and placed in a salt solution it soon dies, but if small quantities of calcium salts be present the heart beats normally. Now, the tissues of the animal are all bathed during health in a solution having a balanced composition, but in some diseases this concentration is changed. Hence, we have abnormal function, or even death. This plays a part in many nervous disorders. Probably it is often the prime factor in chorea, or even some tumorous growths may have their origin in some such fashion. Moreover this discovery explains the action of many of the common cathartics on the human organism. Inasmuch as they are calcium precipitants, they leave an unbalanced condition in the protoplasm—hence, the increased muscular contractions.

The same laws hold in the unicellular and multicellular animals, that is, they must not only have sufficient mineral food, but it must be in the right proportion. Hence, when viewed by themselves, the experiments on the fertilization of the egg appear trivial, but from them has been developed this fundamental law—"Normal life is possible only when necessary salts combine with the colloids of living substances in a definite ratio."

Finally, we have two other properties of living matter—respiration and irritability—which often require special apparatus for their detection but which are just as fundamental as the others. All living things respire and consume oxygen, liberate energy and give off carbon dioxide. This is obvious in the case of man, but not in the case of the potato; but allow water to find its way into the potato pit, and the potatoes are drowned, as man would be. Two kernels of wheat side by side appear the same—one is alive and will grow if placed in suitable soil, the other is dead and will not grow. The two seeds placed in the chamber of a biometer show unmistakable differences in the quantity of carbon dioxide production.

Both the living and the dead seed gives off carbon dioxide, the differences being only in quantity. The living cell, however, is markedly different from the dead in that it is irritable. Prick a man with a pin and he jumps and says, "Ouch," or he may even use stronger language. Prick the living seed with a pin and it also jumps and says, "Ouch," but in language which it requires the

biometer to detect and interpret. It gives off more carbon dioxide. This is true of all cells, even in the nerves which many seem to think obtain their energy from some other source than the metabolized food. This property of increased carbon dioxide output and irritation is so general that it has come to be spoken of as "a chemical sign of life." And by following this gaseous exchange in the higher animals it is possible to determine whether carbohydrates, fats or proteins are being burned, or whether one is being transformed into one of the others.

For years all these transformations were explained by the statement that they were "cell activities." But refined chemical and biological methods have made it possible to push aside the mantle surrounding the cell and to gather some of the engines with which life acts. And to-day many scientists are busy studying these engines—the enzymes. At first attempts were made to obtain the purified product, but, inasmuch as we have no criterion by which purity can be judged and further because of the extreme unstability of the product, the work is extremely difficult. Efforts, therefore, are being made to synthesize the enzymes and to learn the laws governing their activity.

Advances have already been made. Euler has produced an artificial oxidase, Falk an artificial lipase. The synthesis and control of artificial enzymes will revolutionize the science and art of organic synthesis. It may make it possible to control or combat pathological conditions in the human organism.

All the vital steps in digestion are due to enzymes. When they fail, due to disease, will it be possible to replace them by the laboratory product? This is being done in the case of the diabetic who has lost his power to oxidize sugar. He is being given insulin which replaces the product which he can no longer synthesize, and the unfortunate individual is being saved from a living death. The sugar-beet by means of its leaves gathers carbon dioxide and kinetic energy. Through its roots it drinks in water. In the cell they are transformed into sucrose. Some time in the future will the sugar factory be a place in which carbon dioxide of limestone through the intervention of catalysts is made to combine with water, thus producing formaldehyde, which on condensing yields sugar?

Having synthesized the carbohydrates, why not the fats, and finally the proteins, and thus the laboratory in place of the field become the source of the food of man? This I grant is imaginary and to-day sounds like a dream. But we must remember that synthetic alazarine red and indigo blue have replaced the natural products from the madder and indigo plants. Camphor no longer comes only from the camphor tree. The synthetic perfumes are destroying the flower industries of Italy and France. Cocaine has been replaced by the synthetic product, procain, which possesses all the anesthetic properties of the natural product and is devoid of its toxicity. Synthetic products bid fair to accomplish in the case of pneumonia, tuberculosis and cancer what salvarsan and quinine are doing in the case of syphilis and malaria. To-day it is possible that a synthetic drug will conquer that horrible plague, leprosy. Hence, it requires a vivid imagination to even portray the possibilities of the future.

We have seen how rich has been the harvest from a functional study of the living cell. No less interesting and remunerative has been the structural study. All recognize that there are no two men exactly alike. The cattleman tells us that he has no two cattle alike, the sheepherder that there are no two sheep alike, the botanist that no two leaves or blades of grass are alike, and

now the biologist tells us that the proteins composing our tissues are different from those composing the tissues of other individuals. Our individuality goes back to each individual cell. True, they are composed of the same amino acids, but these are arranged in different combinations. Now, from the nineteen amino acids could there be produced enough different proteins for all? Calculating the theoretical number of permutations and combinations we find there to be no less than two million billion different proteins. These, while the stream of life is coursing through the living cell, are held in a certain labile position. When death comes they swing back to the stable.

Throughout the study of the living cell one is impressed with the order, the correlation, the smooth and compact way in which the reaction goes on in the living cell in opposition to the many imitative methods of man. One example will make this clear. Man fixes nitrogen by means of a gigantic arc light in a chimney through which a current of hot air is blown. The flaming disk has a diameter of seven feet and reaches a temperature in the neighborhood of 6,300 degrees F. The product dissolved in water gives us nitric acid. In another method air is cooled to —194 degrees C., the nitrogen boiled off, mixed with hydrogen in the proportion of 1 to 3, heated to a temperature of 1,300 degrees C., and then passed over finely divided uranium. There results ammonia. Thus, in synthetic processes great variations in temperatures and huge, complicated, expensive apparatus are used.

When the bacterial cell fixes nitrogen there is also a real conflagration in which plant residues act as the fuel and the bacterial body the furnace. But how different are the two! The living cell is 90 per cent. water and weighs only one two-hundredth million of a milligram. It works in the dark, damp, warm soil and generates little heat and no light. It produces not simple nitric acid and ammonia but the highly complex proteins.

This living cell is an engine which not only does its work, but it repairs its own wornout parts. It works by means of enzymes. The reactions of each are accurately timed to meet the reactions of all the others and to meet the requirements of the living cell. Old protoplasm is torn out, new is made to take its place. The carbohydrates and fats are systematically fragmented so the energy is nicely liberated to meet the needs of the living organism. However, when the master of ceremonies, life, departs, each works independent of the others. They pull and they tear until they destroy their very home. It is as if they are vying with each other to see which can do the most damage.

"And now to-day in the electron of the atom and in the germ cell of living protoplasm, we have at last come upon God in his workshop and exclaimed, 'It is all machinery!' The spiritualist has said, 'Behind it is the breath of God!' One has found a universe that works, the other a universe that is significant. One has found the tools; the other, the workman. But whether he be a mechanist or vitalist, materialist or spiritualist, both are agreed that the endless discovery of natural law is the only way to cooperate with it. This alone is organic morality; this alone is progress."

THE MYTH ABOUT BACON AND THE INDUCTIVE METHOD

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THE popular belief that Francis Bacon was the founder of modern science is so flagrantly in contradiction with all the facts of the history of science and so patently belied by the contents of Bacon's "Sylva Sylvarum" or the second book of his "Novum Organum" that it is most instructive to inquire how such an absurd belief ever gained currency among educated people. Unfortunately, however, the history of science previous to the seventeenth century is practically a closed book to those without both a classical and a scientific training. Even professional historians like Professor Robinson in his "Mind in the Making" seem to confirm the conventional fable that there was no science before the seventeenth century. Some indications, therefore, of the actual situation must be set down at the beginning.

(1) No one can well dispute the fact that the great body of modern science rests on foundations already laid before the appearance of the "Novum Organum" in 1620. One needs only to mention the work of men like Copernicus, Kepler, Galileo, Stevinus and Gilbert in physics, or of Vesalius and Harvey in biology—omitting, for simplicity of argument, the great mathematicians from Archimedes to Tartaglio and Cardanus. As all these men had long lines of predecessors as well as fellow-workers, Bacon's repeated claim that there was altogether no well-established science based on experience before he came on the scene would in any other man be characterized as the claim of a crank or charlatan. Ignorance on Bacon's part is too generous an excuse. For he certainly must have known something of the epoch-making scientific work of Harvey, whom he knew personally. Does this not make it appear that Bacon's exaggerated claims to originality as to scientific method was the courtier's desire to gain prestige in the eyes of King James? Certainly his treatment of Gilbert's unpublished writings which were entrusted to him did not show any disinterested desire for the spread of truth.

(2) But whatever we may think of the fact and the motives for Bacon's ignoring the scientific work of his own and previous time, there is the still more significant fact that he positively opposed the great constructive scientific achievements of his day—the achievements on which subsequent scientific progress has in fact been based.

(a) He opposed, for instance, the Copernican astronomy which had received notable confirmation in his day through the scientific work of Kepler and Galileo. This fact is so glaring that many of Bacon's admirers have resorted to strange arguments to minimize it. They have attempted to do so either by softening the statement of the fact or by trying to find some justification for Bacon's position. Neither of these arguments, however, is in the least tenable.

Despite the beclouding efforts of Whewell and others, Bacon's opposition to the Copernican astronomy was emphatically explicit. In his "De Augmen. Scient.,"[1] he speaks of "the extravagant idea of diurnal motion of the earth, an opinion which we can demonstrate to be

[1] Book III, Ch. 4.

most false." This he repeats in the "Novum Organum."[2]

Those who try to save the prestige of Bacon by claiming that in his day the evidence for the Copernican astronomy was inadequate, imply that Bacon's sense of evidence was superior to that of Kepler, Galileo and Gilbert. But this can not for a moment be tolerated by any one familiar with the mathematical work of Kepler, with Galileo's demonstration of the phases of Venus and especially with the very flimsy character of the evidence which Bacon himself adduced for the older view. His boasted proof consisted of nothing else but the naïve repetition of the Aristotelian doctrine that "the eternal motion of revolution appears peculiar to the heavenly bodies, rest to this globe."[3]

(b) Bacon also opposed the growing and fruitful method of explaining physical phenomena as far as possible in terms of mechanics. This method, begun by the ancient Greeks and developed by the Italians in the latter part of the sixteenth century, did not appeal to Bacon, who believed in *species spiritualis* as the explanation of sound and that the "human understanding is perverted by observing the power of mechanical arts."[4] Despite a few grudgingly approving words, Gilbert's genuinely experimental philosophy is rejected in principle. His experiments with magnets[5] are called a waste of time, and his fundamental discoveries in electricity and magnetism which have proved basic are characterized as fables.[6]

(3) Not only did Bacon ignore or oppose what was sound in the science of his day, but he himself, despite all his grandiloquent claims, failed to make a single important contribution to science.

[2] Bk. I., Ch. 46; *cf.* Glob. Int., Ch. 6.
[3] "Novum Organum," II, 35; *cf.* II, 36.
[4] *Ibid.*, I, 66.
[5] *Ibid.*, I, 70.
[6] *Ibid.*, II, 48.

The only two claims in this respect that I have ever seen are that Bacon anticipated Newton's discovery of gravitation and that he discovered heat to be a form of motion. Neither of these claims is true.

The first claim is made by Voltaire in the famous essay which did more than anything else to establish Bacon's great European reputation. But the claim that Bacon anticipated Newton's law of gravitation is absurd on the face of it, since the Newtonian theory is based on the Copernican astronomy, which Bacon rejected. Moreover, Voltaire, like other admirers of Bacon, does not seem to have read Bacon with care or noticed his distinct assertion that bodies lose weight below the surface of the earth.[7] Newton could certainly not have been influenced by such nonsense. Bacon's knowledge that the speed of falling bodies increases as they approach the earth —which Voltaire confuses with the law of gravitation—was an old commonplace in no way discovered by Bacon, whose views went no deeper than the observation that some bodies are heavy, some light, and some neither.[8]

The second claim, that Bacon anticipated the modern doctrine of heat as a form of motion, is likewise untenable. For Bacon rejected the atomic theory ("Novum Organum," II, 8), and his method of induction led him to infer that the motion which produces heat "should take place not in the very minutest particles but rather in those of some tolerable dimensions."[9]

How far Bacon himself was from making any fruitful contributions to science is amply illustrated by the observations and conclusions on almost every page of his "Sylva Sylvanum" and other pretended scientific works. A few examples from the more widely read "Novum Organum" may be cited: Refusing to grant

[7] *Ibid.*, I, 33.
[8] Top. Part Sc. Ob. 3.
[9] "Novum Organum," II, 20.

that fire can ever separate the elements of a compound, he recommends the study of the spirit in every body, "whether that spirit is copious and exuberant, or meager and scarce, fine or coarse, aeriform or igniform, etc."[10] Or consider the queer jumble of unrelated phenomena in his tables of instances on which an induction as to heat is to be based, containing the following gems: Confined air is particularly warm in winter, and "the irritation of surrounding cold increases heat as may be seen in fires during a sharp frost." All shaggy substances are warm, and so are spirits of wine. Boiling water surpasses in heat some flames, etc. I am not unaware that with due diligence somewhat similar absurdities may be culled from the pages of Gilbert, Kepler, Galileo, Boyle and even later writers in the Transactions of the Royal Society. But these men have positive achievement in science to their credit. Bacon has none. Nor could he very well have made any scientific discoveries so long as he believed in explaining things by "spirits" and relying on "axioms" whereby "gold or any metal or stone is generated from the original menstruum."[11]

(4) Others have urged that while Bacon did not himself make any direct contribution to science, he founded the true method of science, the method of induction. There is, however, not a single authenticated record of any one ever making any important discovery in science by following Bacon's method and its mechanical tables and twenty-seven prerogative instances. It would, indeed, be most amazing if the man who ignored or rejected what was soundest in the science of his day, and put down as fact or conclusion so many absurdities as Bacon did, should become the originator or true expounder of scientific method.

It is true that some scientists, *e.g.*, Boyle and other founders of the Royal Society, paid great tribute to Bacon. But none of their really scientific contributions was determined by the Baconian method. It was rather the methods which Bacon rejected, the methods of Kepler, Galileo and Gilbert, that they followed in their successful efforts. Also, the idea of a society for the promotion of natural and experimental knowledge was developed by the Italians (*e.g.*, the Lincean Society, of which Galileo was a member) long before Bacon.

We need not ignore the fact that in the first book of the "Novum Organum" and more especially in his doctrine of the idols, Bacon has given us a most vivid, stirring and still applicable account of the perennial difficulties in the scientific study of nature. But his unusually eloquent appeal for the study of facts as opposed to idle speculation was neither new nor in fact very effective in the actual development of science. In the century before Bacon the Spaniard Vives had made the same criticisms, the same exhortations and almost the same grandiose plans. Indeed, we find the same appeal for the direct study of nature continually urged as far back as the twelfth century by the scholastic Adelard of Bath. But it is all rather futile. Science flourishes not on good intentions produced by pious exhortations, but on the suggestion of definite directions of inquiry and definite workable methods, and these Bacon entirely failed to produce.

Bacon's failure is most instructive because it shows the illusory character of the idea of induction which he and Mill after him made popular. According to this view the scientist begins without any regard for previous thought. Resolved not to anticipate nature, he lets the facts record their own tale. All this is purely Utopian. The facts of nature do not stream in on us with all their relevant characteristics duly marked. The number of possible circumstances that can be noted about any object is indefinitely

[10] *Ibid.*, II, 7.
[11] *Ibid.*, II, 5.

large. Scientific progress depends upon considering only the circumstances that turn out to be relevant to the point of our inquiry. But what we consider relevant, *e.g.*, in the inquiry as to the cause of cancer, depends upon previous knowledge. Hence scientific discoveries are not made by those who begin with an unbiased mind in the form of a *tubula rasa,* but by those who have derived fruitful ideas from the study of previous science. In the absence of carefully considered methods of observation that depend upon previous knowledge and critical reflection, the observation of nature herself is sterile. Those who think they can start any natural inquiry without "anticipating nature" or making any assumptions at all are just complacently ignorant. In any case, any one who begins, in the Baconian fashion, to observe nature *de novo* is bound to find many "facts" which are not so. Thus Bacon himself observes that cold diminishes after passing a certain altitude,[12] that air is transformed into water,[13] that clear nights are cooler than cloudy ones,[14] that water in wells is warmer in winter than in summer,[15] and that the moon draws forth heat, induces putrefaction, increases moisture and excites the motions of spirits.[16] Of course many of the absurd observations that crowd the pages of Bacon were made for him by some of his assistants, like the Reverend Rawley, or taken from popular manuals of his day. But they are in any case typical of what untrained observers can and do record. No reader of Bacon can question his genius or the fertility of his mind; but a comparison of his ideas on science with the works of previous scientists upon whom he heaped rhetorical scorn shows the utter irrelevance of Bacon's ideas to the actual progress of science. Thus his classification of the types of motion display great ingenuity. But all such concepts as the "motion of liberty," in which bodies "strive with all their power to rebound and resume their former density," lack the direct relevance which we find in the ideas of the sixteenth-century Italian predecessors of Galileo, like Benedetti. Compare similarly Bacon's vague statements about colors as "solitary" instances or white color as a "migratory" instance with the observations of Kepler's "Dioptrics" or even with the observations on the rainbow in Vitello's Optics published in 1270. The utter futility of the untrained amateur in science is borne in on us when we compare Bacon's ideas on the motion of the pulse, or his explanation of sex organs[17] with the contemporary work of Harvey.

No wonder that a real scientist like Harvey was moved to say that Bacon wrote science like a lord chancellor.

How, then, in the light of the foregoing readily verifiable facts, are we to explain the tremendous extent and persistence of the tradition that looks to Bacon as the founder of modern science?

The first point to note is that Bacon is still eminently readable, while the scientific works of Kepler, Galileo, Gilbert and Harvey, not to mention their predecessors, are inaccessible to the general reader. The change from Latin to the vernacular as the language of the learned, together with the rapid growth of new technical methods since the eighteenth century, has made it difficult for scientists themselves to read the works of their predecessors of the sixteenth or previous centuries. But Bacon can be read by everybody. His pithy sayings are sententious and quotable like Cicero's. The general reader is carried away by the splendid rhetoric with which Bacon denounces as useless all previous work in science; and his errors

12 *Ibid.*, II, 27.
13 "Sylva Sylvanum," 27.
14 *Ibid.*, 326.
15 *Ibid.*, 885.
16 *Ibid.*, 889.
17 "Novum Organum," I, 27.

of fact or irrelevance of ideas are either not recognized as such or else covered by the very broad but unhistorical reflection that they were good enough for Bacon's times.

The main source, however, of the Baconian myth is the great romantic appeal which inheres in the fundamental idea of organizing science on a new basis calling for no special aptitude or technical training. Technical science involves an arduous routine which can not be popular with the uninitiated. The multitude (including scientists away from their special domain) will always delight in any plan for a new deal in science—"a discovery which will lead to the discovery of everything else,"[18] or "a synopsis of all the natures that exist in the universe."[19] That which makes utopias spring up perennially is found in Bacon's idea that if his system could be established "the invention of all causes and sciences would be the labor of but a few years."[20] Especially in an age that believes in democracy and mechanical progress it is pleasant to be told that science exists for material enrichment and that everything can be achieved by rules leaving little to superior wits.[21] It requires painful efforts to disabuse ourselves of such pleasant illusion.

[18] *Ibid.*, I, 129.
[19] *Ibid.*, II, 21.
[20] *Ibid.*, I, 112.
[21] *Ibid.*, I, 111 and I, 122.

GENIUS AND HEALTH

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All mental activity is the associate of physical activity. It is dependent primarily on the working of nervous mechanisms, but these do not function properly without adequate support from the other organs. It is possible for brilliant exhibitions of mental activity to take place in comparatively feeble or badly diseased bodies, as witness the writing of the "Essay on the Human Understanding" by the consumptive Locke, or the composition of his later quartettes by the dropsical Beethoven, but these are of the nature of exceptions. The production of the former was interminably drawn out and the compositions of Beethoven's last years, though rich in quality, were scant in quantity.

Emerson declared that "genius consists in health, in plenipotence of that top of condition which allows of not only exercise but frolic of fancy." Only the healthy frolic either bodily or mentally.

Bernard Shaw, in his "Saint Joan," defines a genius as "a person who, seeing deeper than other people, has a different set of ethical valuations from theirs and has energy enough to give effect to this extra vision and its valuations in whatever manner best suits his or her specific talents." There needs be specific talents, but there must be energy behind these, and of a very real, bread and butter origin. Certainly Joan was an illustrious example of this definition, as she was of the dictum of Emerson.

"History is philosophy teaching by examples" and perhaps even more truthfully and definitely biography is hygiene teaching by examples, for, aside from the peculiar traits of nervous structure inherited or shaped to some degree by experience, the accomplishment of the great man, whether in quantity or quality, depends on his general physical development and the care which he takes of his bodily machine from day to day.

How the Great Man looked

The great man has usually looked the part. Lowell said of Emerson that there "was a majesty about him beyond all the men I have ever known." Washington impressed those about him as being no ordinary man, and Dr. James Thatcher said "the strength and proportion of his joints and muscles appeared to be commensurate with the preeminent powers of his mind." Goethe was likened in his youth to an Apollo, and the physician Hufeland declared that never had he "met with a man in whom bodily and mental organization were so perfect." Tennyson was "one of the finest looking men in the world." Wordsworth was, according to the artist Hayden, "of very fine heroic proportions." Southey looked an ideal poet, Byron was as beautiful as his verse and was likened to "the god of the Vatican, the Apollo Belvidere." Leonardo da Vinci had a figure of beautiful proportions and a noble and engaging presence. Walter Scott was eminently handsome, "much above the usual standard" and "cast in the mould of young Hercules," with a "fresh and brilliant complexion and a countenance of great dignity."

Physique

The great man has not always been of large bulk or of tall stature. Dr. Samuel Johnson was a Polyphemus for size and strength, but De Quincey was, in the language of Carlyle, "one of the smallest

man figures I ever saw . . . you would have taken him for the beautifullest little child." Dumas was six feet tall and well proportioned. Charles Lamb was of diminutive stature and with a "frame so fragile that it seemed as if a breath would overthrow it." The composer and violinist Spohr was of "Herculean proportions," while Weber was "small, meagre, almost insignificant." Thomas Jefferson was six feet, two inches tall, and slender; Franklin was five feet and rotund. The rugged Carlyle was five feet eleven, the deformed and sickly Pope was but four feet six.

Great men have usually been of medium stature, the best height for concentration of bodily power. Beethoven was five feet five, with broad shoulders and firmly built. Siegfried said that it seemed as if "in that limited space was concentrated the pluck of twenty battalions." Brahms was "rather short," "square and solidly built," "the very impersonation of energy." Balzac was five feet high, with, otherwise, "a colossal body," "his whole being breathed intense vitality" and "he both charmed and fascinated the beholder." Napoleon was five feet six, slender in earlier years and not very prepossessing, but at forty he is described by Captain Maitland as a "remarkably strong and well-built man." Chalmers was of "middle height, thick set and brawny but not corpulent," with an "erect, royal air." Macaulay was short, sturdy and "marvelously upright." Victor Hugo was erect, strongly built, with a complexion like that "of a ripe winter apple, fair and rosy as a child's and but little wrinkled."

Energy and Endurance

Michelangelo was neither tall nor short, fat nor thin, but very muscular and so well preserved that, at eighty-six, he is said to have sat drawing for three consecutive hours, until cramps in his limbs reminded him of his advanced years. Rubens was fond of horseback riding, did not use a mahl stick to steady his hand until he was fifty-seven, and though he lived to be sixty-three, none of his works shows trace of enfeebled powers. Titian was still wielding the brush with almost his earlier skill when he was stricken by the plague at about one hundred. His end "came as a surprise to his friends," says Vasari, "since he lived a life so strong and resisting that it seemed able to withstand all the assaults of time."

Napoleon "could work for eighteen hours at a stretch at one subject or many." No eight-hour day for him. "Never," says Roederer, "have I seen his mind weary; never have I seen his mind without spring; not in the strain of body, wrath or the most violent exercise." One of his ministers complained that "it would require a constitution of iron to go through with what we do. After a day's ride in a carriage we no sooner alight than we mount on horseback and sometimes remain in our saddles for ten or twelve hours successively." In his fortieth year Napoleon rode ninety miles without stirrups in five hours and a half. His surgeon Percy said that he was "made of iron, soul and body, always on horseback, galloping about in all weathers, bivouacking, working like ten men, never ill, never tired." Even his enemies declared that Napoleon had a capacity for work equal to that of four other men.

Such powerfully built bodies were storehouses of energy so abundant that it not only displayed itself in work but slopped over into muscular play. Sir Walter Scott was as hearty and hardy as any of the heroes of his novels. As Carlyle said, he "was intrinsically very much the old fighting borderer of prior centuries. . . . In the saddle with foray-spear, he would have acquitted himself as he did at his desk with his pen. . . .

He could have fought at Redswire, cracking crowns with the fiercest, if that had been the task; could have harried cattle in Tyndale repaying injury with compound interest.'' Despite his lameness he walked twenty or thirty miles with pleasure, and as a woodsman he wielded the axe to more effect than any of his tenants.

Browning looked ''a monument of sturdy health.'' As a boy he was the swiftest runner and best ball player in his school. He was a fine horseman, was a tireless walker and was proud of his strength. Only in the latest months of his eighty-four years did he show failure of his mental powers. Wordsworth at sixty walked twenty to thirty miles a day, was without match as a mountain climber and was ''still the crack skater of Rydal Lake.''

Goethe in his younger years excelled all his companions in active sports. He could skate all day and into the night, and his love of swimming was so great that he braved the water in December. Even when beyond eighty he was still so vigorous as to produce truly remarkable works. Richard Porson, the famous Greek scholar, ''had great bodily strength and often walked from Cambridge to London, a distance of fifty-two miles, to attend his club in the evening.'' Alexander Von Humboldt in some of his expeditions was on foot for fourteen hours a day, and at sixty ''climbed high mountains without show of fatigue.'' ''In my travels,'' he says, ''I kept my health everywhere. I passed through the midst of black vomit and yellow fever untouched.''

Many great generals were remarkably robust. Prince Eugene was possessed of great muscular strength, as was also Marshal Saxe and Turenne. Washington excelled even the hardy hunters and woodsmen in athletic feats. He said of himself, ''I have a constitution hardy enough to encounter and undergo the most severe trials and I flatter myself resolution to face what any man dares.'' He was a strong swimmer, was very fond of dancing and horseback riding. His diary shows that he rode on many occasions as much as sixty miles a day, and Lawrence Washington tells us that he ''usually rode from Rockingham to Princeton,'' a distance of five miles, ''in forty minutes.'' His only demand of a horse was that ''it would go along.'' Any viciousness of the animal mattered not at all to this bold rider. At Mount Vernon his favorite sport was fox hunting, and, three times a week he had, by candle light, his breakfast of ''three small Indian hoe cakes and as many dishes of tea'' and was off with the hounds before sunrise. Thomas Jefferson spent so much time over his studies that he had for his sole exercise while in college a rapid run in the evening to a certain stone a mile distant in the country and return. Like Washington, he was, in his earlier years, fond of dancing. He often walked fourteen miles at a stretch, and to within a few days of his death it was his habit ''no matter what his occupation, or what office he held, to spend the hours between one and three in the afternoon on horseback.'' At the age of seventy he sometimes rode as much as forty miles. Franklin was a great swimmer. On one occasion he swam for four miles in the Thames, ''performing in the way many feats of activity, both upon and under the water.'' He obtained such a reputation as a water dog that he thought seriously of becoming a teacher of swimming. Even at forty he still swam for two hours at a stretch. He astonished his fellow printers by carrying two forms of type to their one, and, in his old age, he was fond of displaying his strength by lifting heavy books. Because of his size and strength Dr. Samuel Johnson was advised by a certain luckless publisher to get a porter's knot and turn porter.

Set upon one night by four footpads, he kept them at bay until the watch came up. He frequently in his younger years walked from Litchfield to Birmingham and back again, a distance of thirty miles, without fatigue, and in his trip to the Hebrides Boswell says that "ninety-five days were never passed by any man in more vigorous exercise." He was a bold swimmer, and though he ordinarily moved like a manacled elephant, he at sixty-eight writes delightedly, "I ran a race this day and beat Baretti." Robert Burns was very robust until alcohol and a morbid outlook on life got the better of him, and his finest songs came to him while following the plough when most of us would be too exhausted to use our brains. Byron was a skilful and strong boxer and he swam the Hellespont in an hour and ten minutes. Poe, before he became a victim of alcohol, was a good runner and jumper, but was especially distinguished as a swimmer. When fifteen he swam in the James River for six miles against a strong tide without apparent fatigue. Dean Swift enjoyed walking and boating, but preferred riding, thinking it good for liver and brain. He punningly wrote to Archbishop King that he "rowed after health like a waterman, and rode after it like a post boy."

Keats was very robust until after twenty-two. He was short but broad-shouldered and was the best fighter in his school. He lived a "clean and strenuous life." After the development of tuberculosis he tramped thirty miles a day in sun or rain in a vain attempt to rid himself of his malady. The poet, Southey, thought nothing of a walk of twenty-five miles when upward of sixty, while Shelley, who was especially fond of boating, though slightly built, "could take an oar and could stick to a seat for any time against any force of current or of wind, not only without complaining, but without being compelled to give in until the set task was accomplished, though it should involve some miles of hard pulling."

Dickens found rest and recreation in walking—"twelve, fifteen, even twenty miles a day were none too much for him," and on one occasion he turned out early and did thirty miles before breakfast. "Swinging his blackthorn stick," says Fields, "his little figure sprang forward over the ground, and it took a practiced pair of legs to keep alongside of his voice." Mark Twain's biographer, Paine, says of him "in no other man have I ever seen such physical endurance."

Though seemingly "an air fed man," Charles Lamb was "as wiry as an Arab" and "could walk all day." Carlyle at eighty-two still walked five miles a day. Tolstoi was an expert swimmer, enjoying the water after sixty-five. At sixty-six he learned to ride a bicycle and to do so without the handle bar. He was an excellent rider, and in his later years he delighted in all manner of manual work. At fifty-eight Tolstoi walked from Moscow to Yasnasa, a distance of one hundred and thirty miles, in three days. He started with three young men, two of whom broke down by the way. Tolstoi reached the end of his journey in a merry mood and declared he had never enjoyed anything so much in his life. John Wesley, while of slight physique, was an expert swimmer and his journal has been called "the most amazing record of human exertion ever penned." Eight thousand miles was his annual record for travel on foot and on horseback for many a long year, and "he spoke oftener and to more people than any man who ever lived." Coleridge, one day of the year in which he wrote the Ancient Mariner, walked forty miles without apparent fatigue. Beethoven, whether it rained or snowed or hailed, or the thermometer stood an inch or two below the freezing point, took his walk in double quick time of five miles or more

into the country. Brahms was a tireless mountain climber, and Wagner was the best "tumbler and somersault-turner of the large Dresden school," was a daring mountain climber and when nearly seventy delighted to astonish his friends by standing on his head. Tchaikowsky read somewhere that, in order to keep in health, a man ought to walk for two hours a day and he followed this rule "with as much conscientiousness and superstition as though some terrible catastrophe would follow should he return five minutes too soon. Leonardo da Vinci excelled all the youth of his city in athletic feats and Turner walked twenty miles or more a day, working as he walked. Emerson at twenty took a pleasure walk of forty miles into Connecticut and at thirty-four mentions in his journal a walk with Hawthorne of twelve miles. Even the delicately made and "washable away" DeQuincey considered fourteen miles as essential to his health, and at seventy he often walked seventeen miles a day.

Sources of Energy

But such display of energy on the part of the great man means that there was a source of energy behind it. There must be an adequate supply of fuel to keep the engine working at such a pitch of perfection. Francis Galton, in his study of men of genius, observed that "most notabilities have been great eaters and excellent digesters on literally the same principle that the furnace which can raise more steam than usual for one of its size must burn more fully and well than common." Tom Tyers remarked of Dr. Johnson that "his bulk seemed to require now and then to be repaired by kitchen physic." Though Johnson declared that he "had never been hungry but once," he always ate "with the fierceness of the famished." "I never knew a man," says Boswell, "who relished good eating more than he did." He was an exacting guest, and when a meal to which he was invited was a disappointment to him he would remark to Boswell, "this was a good dinner enough, to be sure, but was not a dinner to ask a man to." His remarks on feeding are characteristic, honest and wise. "Some people," he said, "have a foolish way of not minding, or pretending not to mind what they eat. For my part, I mind my belly very studiously and carefully; for I look upon it that he who does not mind his belly will hardly mind anything else." The great man is more often but half conscious of what he eats. He is seldom, and the greatest man never, an epicure. He is concerned with larger matters. Napoleon in his earlier years gave very little thought to his eating. He ate hurriedly, his dinner lasting from seven to twelve minutes. He preferred plain dishes and was most fond of chicken, red mullet, roast mutton, beans, lentils and macaroni. He had chocolate or ices served in the midst of his work. As emperor he became more interested in pastries and grew obese from excess of food, but, for his time, he was considered a temperate feeder.

Washington's breakfast consisted of three small corn cakes, sometimes with honey, and of three dishes of tea. At dinner "he ate heartily, but was not particular in his diet, with the exception of fish, of which he was exceedingly fond." He partook sparingly of dessert and when served any dish that was very rich he refused it with the remark, "That is too good for me." His supper consisted of two cups of tea with or without toast. Jefferson ate heartily but mostly of vegetables, of which he raised a great variety. Franklin in his printer days tried vegetarianism partly for the sake of economy, partly for bodily benefit. He, however, returned later to the use of meats, and, as in the case of Napoleon, in his years of prosperity the pleas-

ure of the table often got the better of his bodily activities, and he suffered the consequences in attacks of gout. However, he was quite aware of his fault and so kept his intemperance within such bounds that to the latest years of his long life he was in condition for superior mental work.

Dean Swift "cared not for luxurious feeding. He would enjoy a herring with Vans or bacon and beans with Addison as much as he did turtle with the Premier. When Bolingbroke sent him the menu of a luxurious dinner" he replied, "Pooh! I care nothing for your bill of fare, send me a bill of your company."

Michelangelo is pictured in his last years by Condivi as "healthy above all things, as well by reason of his natural constitution as of the exercise he takes, and habitual continence in food." When intent on some work he "confined his diet to a piece of bread which he ate in the midst of his labors." He was pleased with a present of fifteen margarine cheeses and fourteen pounds of sausage—"the latter very welcome, as was also the cheese." Beethoven paid little attention to his eating but was fond of fish and of macaroni with Parmesan cheese. His breakfast was usually coffee and his supper a plate of soup. Brahms "was extraordinarily modest in his daily life. Thirty-five to forty cents was the most he spent for his dinner and this includes (the cost of) a glass of beer or a half pint of wine." Both he and Beethoven were very fond of coffee. Wagner was frequently changing his diet to test its effect. His biographer says that "what he underwent in vain attempts to diet himself into robust health is almost past belief." He was always a meat eater. "I eat no sweet stuffs," he writes, "only meat, as one may hear, I believe, in my music."

Dumas was interested in affairs of the kitchen and was a master cook. He invented a salad "without vinegar or oil" and other dishes. He "was moderate and select in the matter of his own food" and was "abstemious in drink." In the midst of one of the cholera epidemics his son found him seated alone and devouring several melons. "Don't you trouble," he said in reply to the exclamation of horror, "this is just the right time to eat them—you can get them for nothing."

Scott did most of his literary work before breakfast and this was his chief meal. "No fox hunter," says Lockhart, "ever prepared himself for the field with more plentiful delicacies of a Scotch breakfast, with some solid article, on which he did most hearty execution—a round of beef—a pastry, such as made Gil Blas' eyes water, or, most welcome of all, a cold sheep's head. . . . A huge brown loaf flanked his elbow. . . . But this robust supply would have served him in fact for the day. He never tasted anything more before dinner, and at dinner he ate sparingly." Field said of Dickens that he had rarely seen a man eat and drink less.

Emerson took whatever was set before him and enjoyed it. Pie formed a part of his breakfast and was the first thing attacked. He had two cups of coffee for breakfast and tea for supper. "Rarely he noticed and praised some dish in an amusing manner, but should any mention of ingredients arise he always interrupted with, 'No! No! it is made of violets; it has no common history,' or expressions to that purpose. He tried vegetarianism at the suggestion of Alcott, but finding no benefit in it he returned to the use of meat once a day." Goethe had a cup of chocolate at eleven and his dinner at two. For this meal "his appetite was immense. Even on days when he expressed himself as not being hungry he ate much more than most men. Puddings, sweets and cake were always welcome." Between eight and nine he had a frugal supper of a

little salad and preserves." DeQuincey noted that Charles Lamb was peculiarly temperate in eating, and the same could be said of DeQuincey, for coffee, rice, milk and a square inch or two of mutton were the materials that invariably made up his meals.

The great genius has sometimes become so absorbed in his labor that he has neglected for long periods to take in fuel, and when he did so, he has had to make up for the omission. Balzac during his spells of composing would work for "eighteen to twenty hours daily for weeks, seeing no one, eating sparingly, sipping his coffee, and refreshing his jaded anatomy by taking a bath, in which he would lie for a whole hour plunged in meditation." After such a fast he once appeared suddenly and at a restaurant ordered and practically consumed all the following: "a hundred oysters; twelve chops; a young duck; a pair of roast partridges; a sole; a relish; sweets; fruit (more than a dozen pears being swallowed); choice wines; coffee and liquids."

The great man has been as temperate in drink as in meats. He is too keenly conscious of the depressing effects of alcohol not to avoid its influence. Some few, like Bismarck and Dr. Johnson, could consume enormous quantities without apparent effect, but the latter abandoned his excessive consumption, observing that "wine gives a man nothing. It neither gives him knowledge nor wit; it only animates a man, and enables him to bring out what a dread of company has suppressed. . . . But this may be good or it may be bad." It is "one of the disadvantages of wine that it makes a man mistake words for thought." Schubert and Burns purposely drowned their hypersensitive souls in wine, and suffered the consequences as did Poe, while Thackeray shortened his days with dinners and drinks. Herbert Spencer took opium for sleeplessness and Coleridge and DeQuincey because of bodily pain, and the latter manfully threw off the yoke of bondage after he had reached a dose of eight thousand drops. Even in an age when alcohol was a part of every meal, Wordsworth and Shelley drank only water, and while Keats possibly found inspiration from wine, DeQuincey's "most deadly certainty of failure was the touching of anything in the nature of wine or spirits." Wagner was disgusted with the wine bibbing and beer indulged in by those who celebrated his birthday.

Rest

It is often said of great men that they needed and took but few hours of sleep. It is true that in their desire to accomplish as much work as possible they have spent no more hours in bed than was necessary, but those who found that less than six or eight hours would suffice them were very few. Alexander von Humboldt, Linnaeus, Cuvier, Dumas, Bismarck and the composer Dvorak are all the four-hour sleepers I have come upon in a long list of distinguished men. Napoleon, who is sometimes mentioned in this class, took from six to eight hours and did not hesitate to nap in the daytime and even in the midst of conversation. He could go for long periods without sleep, but he always condemned himself to correspondingly long periods of rest afterward, sleeping on one occasion for thirty-six hours at a stretch.

Goethe was a very sound sleeper, and Descartes, who is said to have done more original work than any man of his century, slept a great deal. Brahms could sleep at will and under any conditions and Dumas, "after writing for some hours at a stretch, would suddenly fling himself on his bed, and in a few seconds be sound asleep; fifteen or twenty minutes later he would wake up again with equal abruptness and return to work—a giant refreshed."

The great man has, because of his concern for fitness for his task, tried to keep himself in superior health, though this was not always possible. A few brilliant geniuses have fallen early victims to the bacterial scourge of the day which fell upon the strong and weak. Raphael was carried off by bubonic plague, Mozart by typhus fever, Keats, Chopin and Weber and others by tuberculosis. A few great men, a very few, through over-sensitiveness to their treatment by the world, lost their genius and their lives by dissipation. Sad examples of these are Burns, Schubert and Poe. Jonathan Swift was early attacked by a disease of the ear which extended to his brain and clouded his later life. He fought it tooth and nail, though without effect. He wrote at fifty-five, "without health and good humor I would rather be a dog."

The Shackles of Sickness

A few great people, robust in early life—Darwin, Carlyle, Spencer, George Eliot and others—suffered from ill health in middle life and were limited in their working hours probably from the disastrous results of eyestrain. Herbert Spencer, at the age of thirteen, in a fit of homesickness, walked from school to his home, covering forty-eight miles the first day, forty-seven miles the second and twenty the third. Though he seemed little the worse for this journey, this, with his later engineering work of eighteen hours a day, may have been sufficient to injure his highly strung nervous system.

Taine, the eminent French scholar, set for himself in youth a daily program of mental toil, with only twenty minutes' play after dinner and an hour of music in the evening. Not an eight hour, but a sixteen hour day. By thirty his mental machinery was working badly, and his program had for years to be reversed, so that he read or wrote for an hour or two and spent the rest of the time in gardening, in twelve-mile walks and the like vegetative occupations. Writing at thirty-four he says: "I am like a violin of which the pegs are too small; having become worn out from being constantly turned, they no longer bite the wood but slip and let the strings become loose, so loose that the sound is spoilt and often altogether absent." Nevertheless, a man who can undertake twelve-mile walks is no weakling and perhaps Dr. Gould was right in attributing his ailments and distress in mental work to eyestrain; he certainly showed some symptoms, but the "intellectual" pace set in his early program was nevertheless a hazardous one.

Lord Bacon spoke of himself as "a man of no great share of health who must therefore lose much time." Spinoza early suffered from disease and was an invalid by forty. John Locke kept his frail body in health until thirty-five, but from that time he suffered from lung disease which "painfully impeded his schemes of work and occasionally induced states of mind altogether at variance with its otherwise robust character." He was twenty years in writing his famous "Essay on the Human Understanding." It was done, he tells us, "by incoherent parcels and after long intervals of neglect." No man was more keenly impressed with the value of health, and his "Thoughts on Education" begins with the words, "Our clay cottage is not to be neglected"—for "he whose body is crazy and feeble will never be able to advance in it."

Immanuel Kant is the most remarkable of the great men of frail physique. "Possibly a more meager, arid, parched anatomy of a man has not appeared on this earth." He was so delicate that it is said that he took cold from handling damp proof-sheets. Yet by the utmost care he kept himself for nearly fourscore years in the nicest of health, "like a gymnastic artist," as he expressed it, "balancing himself upon the slack rope

of life without once swerving to the right or to the left." However, despite the great sway of his influence over the thought of the world, he found himself disturbed in his larger plans by the narrow limits of bodily power within which they must be worked out.

Edwin Booth was limited in his physical endurance and found himself too exhausted after his acting for further exercise, while Lord Lyons, one of Great Britain's most distinguished diplomats, worked most exceptionally to within a month of his death at seventy, with only so much muscular exercise as was necessary to get him about his house and to his carriage.

St. Bernard, St. Francis and Savonarola are said to have injured their health by over-enthusiastic fasting and other ascetic practices, while Martin Luther, after starving himself in the monastery to the point of emaciation, went, after his break with Rome, to the opposite extreme and suffered the consequences of high living. He drank wine, as he put it, "to spite the devil," that is, the devil in the form of monasticism. He meant well, however, for he said, "We ought to do our part, and take care of our bodies; but when we are tempted, abstinence is a hundred times worse than eating and drinking."

Many great men, like Johnson and Dickens and Gibbon and Macaulay and Watt and Turenne, were very delicate children who by special care attained superior health and lived a long life. Another of this group, Descartes, said of himself: "The conservation of health has always been the principal end of my studies."

Physique and Profession

Of the great men already mentioned it will be noted that the artists and musicians and poets are, contrary to the usual notion, quite as robust as the soldiers or statesmen. It was pointed out by Francis Galton that of all groups of the great the clergymen who have attained distinction show the greatest number of physically inferior men. There are good reasons for this in that to within very recent times the spirit of asceticism so swayed the church that the body was too often looked upon with indifference, if not with contempt, by its ministers, the ministry itself was looked upon as fit only for the feeble and was, because of the general atmosphere of asceticism in which it was shrouded, shunned by the more robust. Phillips Brooks said that he felt he was giving up his manhood when he entered upon the work of the ministry. All this is changed and with it the physique of the minister is changing. The delicate child is no longer considered by his parents as predestined a preacher. In a recent installation of a clergyman in a pulpit of direct Puritan descent, a conspicuous part of the charge to the new incumbent referred to the care he should take to preserve his health and strength, since on these the whole success of his work would depend.

Francis Thompson has pointed out that we moderns are scourged quite enough with dyspepsia and other ailments without the use of the whip or the hair shirt. As shining examples of the robust great man in the pulpit, we have, besides Phillips Brooks, who was never sick, Beecher, who knew no fatigue he could not sleep out in a night, Spurgeon, Chalmers and many other giants.

Philosophy has also enrolled in her ranks many men of frail physique, as Kant and Spinoza and Bacon, but it has also had among its followers such robust beings as the hardy, hoplite soldier Socrates, the "healthy and high spirited Mill," and Hobbs, who at seventy was an enthusiastic tennis player and who still wielded his pen at ninety.

The Great Man as Health Teacher

The man ambitious to work out his life task in the most perfect manner has

felt more keenly than the man of lesser inspiration the need for the most sensitive and enduring bodily instrument with which to accomplish his work. Feeling so keenly the handicap of ill health he has had a finer insight into the laws of health. The most eloquent sermons on hygiene are to be found, not in the professional health books of the day but in the writings of such men as Molière, Cervantes, Montaigne, Michelangelo, Walter Scott, John Wesley, Carlyle, Bacon, Smollett, Rabelais, Locke, Voltaire, Johnson, Swift, Berkeley, Beecher, Franklin, DeQuincey, Kingsley, Browning, Francis Thompson and Emerson.

Though these and many more great men have preached the precepts of health, they would have been the last to have given health undue concern or to have desired others to do so. In fact it is one of the secrets of their own health and accomplishment that they made the quality and quantity of their work the test of health. Idleness and introspection are ruinous to health. Health is developed most by the exercise of all one's faculties in absorbing work. One must lose himself to find himself. The real invalid Molière laughs at the man who makes himself miserable with imaginary ills, and Joseph Addison, suffering as he was from asthma, devoted one of his essays to the folly of paying undue attention to health. "I do not mean," he says, "that I think any one to blame for taking due care of their health, on the contrary . . . a man can not be at too much pains to cultivate and preserve it. But this care . . . should never engage us in groundless fears, melancholy apprehensions and imaginary distempers, which are natural to every man who is more anxious to live than how to live."

The composite picture obtained from this study of great men—the picture of *the great man* is that of a being who made the most of his bodily possessions. Usually these were strikingly superior. Seemingly they unfolded apace to fit the aspirations of the spirit within, for it was noted by Plato that it is not the good body that improves the soul so much as the good soul that improves the body. Not only does the great man, the truly great man, care, according to his knowledge, for his own body, but he is so keenly sensitive to any hampering by bodily imperfections or missteps that he has often felt called upon to preach the gospel of health to others, and his sermons have been of the highest value. The exceptions to the picture which we have noted have been the lesser men. Because they were exceptions, they fall outside the composite and if they blur it, they also produce a shadow which intensifies the figure it surrounds.

We can not all satisfy our ambition to be great, but we may at any rate come nearer attaining that end if we look with the respect of the great man upon the physical foundations on which all our work and pleasure depend. The exclamation of the slowly dying John Locke sounds across two centuries like a trumpet call: "While we are alive let us live," for, to repeat the words of Michelangelo, "a man does not come back again after death to patch up things ill done."

THE LIES THAT CHILDREN TELL

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FLASHING brighter and brighter in the firmament of modern science is the rising star of child study. Yet the growing interest manifested in the scientific understanding of child behavior is of rather recent origin. Before the present century, as a matter of fact, scientific child study can hardly be said actually to have existed. True it is, of course, that such eminent formulators of pedagogic theory as Rousseau and Pestalozzi —and a few others—attempted to repose their multifarious educational precepts upon their understanding of child nature. Unfortunately, however, their knowledge of children was circumscribed and scanty. Saturated, moreover, with philosophic theory the traditional methods of research of the old type of child study were based for the most part upon introspection and uncontrolled observation. Whatever permanent results such methods achieved were due in large measure to the pedagogic intuition of a few far-sighted investigators rather than to any keenness or intrepidity of research. Moreover, when the penetrating light of science actually began to illuminate the field of child study, the attempt was usually made to seep over the entire area of child development in as *general* a way as possible. This generalizing attitude was due largely to the influence of the early pioneers in child study for whom there was of course little need for specialization since the field itself was as yet quite untilled.

However, this early attitude, while still existent among a few eminent child psychologists, especially in the Old World, is, nevertheless, gradually disappearing. In our own country to-day child study is indeed a field of specialization. This is the result in part of the rapid development of the field in general and also the constantly increasing number of new problems. Moreover, in view of the growing tendency to see in psychology a study of human *behavior* rather than of the human *mind*, child study is gradually emancipating itself from the impeding tentacles of tradition. As a result it is beginning to study children more and more from the point of view of their daily actions and performances. This fact alone would be sufficient to drive even the most versatile student of children into the arms of specialization, for child behavior in its entirety is so multiple and so kaleidoscopic as to be utterly beyond the thorough mastery of even the most capable and energetic scholar.

This article is an attempt to consider only one aspect of the child's many-sided behavior—the lie. We have chosen this particular phase of child life not only because it is unquestionably one of far-reaching interest but also because so little about it has appeared in American publications—scientific as well as popular. The dearth of first-hand scientific material on child lies is due for the most part to the belated development of this special field of study—the reasons for which have already been set forth. Four important aspects of our problem will characterize the following discussion: (1) the causes of the child lie; (2) the pseudo or apparent lie; (3) the real lie; (4) the treatment and prevention of lies.

II

Scholars vary considerably in their attempts to explain the causes of the child lie. Adopting the attitude of Rousseau there are those who believe that the child as it is born into this world is entirely good, that its "degeneration" is the result of the evil influences of man and his contaminating environment. The adherents of this viewpoint are generally known as *empiricists*. With Rousseau they hold that "the lies of children are the work of their educators." Opposed to the doctrines of the empiricists are those of the *nativists* who stress the belief that whatever the child is, it is by virtue of its inheritance. For the nativists environment plays but a small and inconsequential rôle in the drama of life. The child, it is their contention, is not merely amoral: it is actually antimoral. The lie, as the nativist sees it, is only the beginning of an individual's unbridled egoism. Between these two extreme viewpoints which ascribe the child lie either wholly to the influences of environment or on the other hand solely to those of inheritance is the more moderate and reasonable attitude of *convergence*. The proponents of this manner of thought see in the child lie a very complex aspect of human behavior which can be fully explained neither on grounds of heredity nor on those of environment. The protagonists of convergence believe that the genesis of the child lie is the result of an interweaving of the influences of nature and nurture. Doubtless this third attitude is the most plausible. Scientifically, also, it is the most tenable.

Close analysis will show that the lies of children are multiform; that often they defy exact classification, and that they can not always be patterned according to any definite standards. To say, therefore, categorically—without further evidence than that now available—that such a complex form of human behavior as the child lie is instinctive, or that, in other words, it is an unlearned, inherited type of human activity, is a scientific absurdity. No modern student of child behavior, guided to his conclusions by careful and painstaking research, would subscribe to such a one-sided opinion. As a matter of fact, the question has been raised by some psychologists whether normal children under the age of four actually, if ever, tell a lie. And yet, if the standpoint of the adherents of the convergence idea is correct, then certain qualifying elements of the child's lie must be due to factors of inheritance as well as to those of environment. It is doubtless true that in spite of their indefinable variety child lies usually—though not necessarily always—are colored by certain tints which are ordinarily determined by inheritance.

First and foremost among such qualifying elements is the matter of self-preservation. This causes the child to assume an attitude of defense towards imminent danger or threatened unpleasantness. Frequently, moreover, such an attitude is conditioned by fear. In fact, one of the greatest contributors to falsehood among children is their fear of punishment. Thus, rather than to face punishment for some alleged misdeed, great or small, children will rush to their most natural avenue of escape—the lie.

Then again, the child may be impelled to deviate from truth or reality by its imagination or fancy. This after all, however, is merely a playful relationship between the child's mental status and the outside world of cold facts:

> Idealizing temperaments [says G. Stanley Hall] sometimes prompt children of three or four suddenly to assert that they saw a pig with five ears, apples on a cherry-tree, and other Munchausen wonders, which really means merely that they have had a new mental combination independently of experience.

Whether such flights on the wings of fancy should actually be designated as

lies is highly questionable and will be considered at greater length further on in this discussion.

Rather similar to the child's inborn inclination to imagine reality of things that are unreal is its tendency to mimic and to imitate. Children will thus pretend all sorts of things. To quote G. Stanley Hall once more: "They are animals, doctors, ogres, play school . . . are dead, mimic all they see and hear." Here again it is open to doubt whether the child is actually lying in the real sense of the term.

Another factor to be considered in the lies of children is the child's volitional nature. This, too, is more or less inborn and consequently rather independent of environment. Weakness and dependence of will subjugate the child to swarms of suggestive impressions which not infrequently will cause the child to err in questions of fact. Strength and independence of will on the other hand serve as dynamic weapons in the child's battle against the hordes of temptations leading to falsehood.

All the foregoing aspects of untruth—self-preservation, imagination, mimicry, power of will—are only formal determiners of behavior. They represent only partial components of a lie. A child may be telling a falsehood and yet not be impelled by any single one of these influences of heredity. As a matter of fact, lies in most situations are determined not alone by any single member of this quartet of inborn tendencies but also by a multiplicity of external factors produced by environment. It is the preponderance of these environmental conditions which makes it possible to prescribe methods of treatment for juvenile lies, except, of course, in those cases that are purely pathological.

Perhaps the most convincing argument in favor of environment as a conducive agent to veracity is the fact that lies are much less prevalent among children of the socially better classes than amongst those of the lower social strata. This has been ably demonstrated by a number of European investigators, foremost among them being Dr. William Stern, professor of child psychology at the University of Hamburg. Of course, in a certain number of individual cases it may also be true that the child of the lower classes, besides being placed in a most unfavorable environment, is also endowed with certain innate proclivities tending to foster untruth. Yet, even if such native tendencies were entirely absent, the relative lack of veracity among such children should not be altogether unexpected. In the first place, such youngsters frequently are entirely lacking in proper and able guidance. During the greater part of the day both of the child's parents are usually away from home. The child is thus left to amuse himself, or what may often be even worse, he is thrust into the company of questionable companions. Left to itself the child will naturally give way to unfettered flights of fancy. Frequently it may become entangled in the web of suggestion which will cause it to do things which in the end are sure to bring about punishment. Playing with its pals the child will often be duped and deliberately misled to perpetrate deeds the detection of which will inevitably result in punishment. And then when the young miscreant is discovered, the punishment he receives usually serves as a vent to the coarsest kind of parental anger rather than as a remedial means of curing a juvenile defect. What could be more natural, then, than that the child should renounce truth? The very injustice of its punishment becomes the birth pang of future falsehood. There is little doubt that if such children were given proper guidance under propitious home conditions their propensity to lie would decrease very largely and they would grow up at least as average truthful individuals.

It must, of course, not be assumed that children of the so-called cultured classes do not lie. As a matter of fact conditions in such homes are often of the very kind that incite children to falsehood. Here, too, the child is not infrequently without judicious parental training. The number of families in which both parents go to business seems to be increasing. Needless to point out that servants —even the well intentioned—are not always the best child trainers—especially in the matter of veracity. Moreover, in our concentrated and complex city civilization the number of families living beyond their income in order "to keep up" in social position and dignity with other families is also on the increase. Children in such families are quick to be inoculated with the germ of duplicity. As a matter of fact, their parents, in their efforts to throw dust in the neighbors' eyes and thus conceal the family's true economic status, have in all likelihood cautioned their offspring to practice a similar form of deceit. Furthermore, there are also of course the multifarious "white lies" of convention with which children are thrown into constant contact. Even some of the most respectable families, guided by a very lofty sense of ethics, see no harm in such trifling falsehoods and make little effort to protect their children from their influence. While such petty artifices may deceive no one and may be quite harmless as far as adults are concerned, for children they are positively dangerous. More than any other factor, perhaps, they call the child's attention in a very direct way to the fact that there is such a thing as *conscious divergence from truth*, and that this, moreover, is indulged in by their elders with apparent impunity. Not only may this stimulate the child itself to lie; but frequently also it shatters beyond repair the child's unquestioning confidence and trust in its elders. And when this is gone, child training—in *all* respects—becomes a most difficult and hazardous undertaking.

Besides these few environmental causes of child lies there are countless others. An exhaustive discussion of all within the realms of this brief paper is manifestly impossible. One such influence, however, is so common that even a most cursory discussion such as this must make mention of it. Prevalent in most families throughout the world is the tendency on the part of parents to ask altogether too many questions of their children. The average parent delights in playing the rôle of some Grand Inquisitor and expects his children to answer his many questions with unfaltering ease and unimpeachable accuracy. Now, the question, unless employed by one well versed in the art of interrogation, is one of the most puissant contributory causes of the child lie. It has in fact been shown that answers based upon questions tend to be at least five times more erroneous than statements made spontaneously.

> Continual cross-questioning [says Dr. Stern] not only leads to unconscious splits of memory, but, in the end, to conscious untruths. The questioner seems determined to have an answer, so the child obliges him by saying something that will put an end to the uncomfortable examination.

The danger in subjecting the child to unnecessary questions is resident chiefly in the power of suggestion which may generate in the child's mind false ideas which otherwise might be entirely absent. To be eschewed especially is the leading question—that type of interrogation which seems to contain the answer within itself, but which to the unthinking child often becomes a treacherous snare.

> For the question "Was the cloth not red?" the answer "Yes" is always readier than "No." The naïve human being is much inclined to affirm any idea presented to him, *i.e.*, to accord it with objective existence [Stern].

If such questions tend to mislead intelligent adults, what must their effect be upon immature and uneducated children?

Epitomizing what has been set forth so far, we note that the child lie is a form of human behavior of incalculable intricacy; that its origin and causes are traceable sometimes to the influences of heredity, but more often to environment; most frequently of all, however, to the combined action of the intermingled and wide-reaching forces of nature and nurture.

III

The difference between truth and its opposites is ordinarily plain to perceive. Yet its very simplicity often tends to becloud the distinction. From our previous exposition, however, it should be more or less clear that in a scientific sense it is not always satisfactory to label every digression from fact as a lie. We have intimated that in certain instances, especially in those where the child is deviating from truth by virtue of its inherent imagination or its tendency to mimic and to imitate, it is psychologically doubtful whether the child is actually lying. Such cases of apparent prevarication the student of child behavior prefers to call *pseudo-lies* in contradistinction to *real lies*, the salient difference between the two being that in the case of the former the deceiver is not moved by any distinct purpose to deceive. A real lie is always a consciously false statement that aims to achieve certain results by the deception of others. It is the lack of this purposive element which characterizes the pseudo-lie and differentiates an imaginative invention from a real lie. Most prominent among the innumerable types of pseudo-lies are those spurious untruths due to imagination, fancy, play, mimicry, imitation, tricks, etc. As a matter of fact, of the normal child's lies more than half would be of this group.

Bearing these facts in mind let us now throw the light of our discussion upon a few concrete examples of some of the many types of pseudo-lies. A veritable treasure-house of such is afforded us in the autobiographies of eminent men. The life stories of authors, painters, sculptors are especially replete with such types of childish invention.

Gottfried Keller, the Swiss raconteur, reports in his autobiography that when he was still quite a youngster he once spread the news of his discovery of a chest containing incalculable masses of gold and silver. So real and vivid were the details of his invention that many of his companions—and even some of his elders who should have known better—began to look for the alleged place of discovery. When one of his youthful companions ventured to play the rôle of a doubting Thomas, young Keller sought to reinforce the quivering threads of his invention by showing his sceptical questioner some gold and silver coins—which, however, he had received as a birthday gift.

On another occasion Keller startled his comrades by maintaining that he had given gold and silver necklaces and bejeweled bracelets to a wealthy lady from the city who happened to be passing the warm days of summer in the coolness of Keller's native village.

Goethe, in his "Dichtung und Wahrheit," tells us how he, as a boy, was wont deliberately to mislead his companions by passing off self-imagined tales as his own experiences.

> . . . it made them marvel to think that such wondrous things should have befallen me, their comrade. These inventions, of whose truth my comrades made passionate attempts to convince themselves, were held in great esteem. Alone, each one for himself, used to seek out the alleged place of my experiences. . . .

The cases of Keller and Goethe are representative pseudo-lies caused by a powerful imagination. Both lads, no doubt, were stimulated by the vividness

of the mental pictures which they had absorbed from their readings.

The late Professor Meumann has reported several interesting cases of pseudo-prevarication. The following stands out especially:

> I knew a little girl of four years of age which, absolutely unabashed, claimed as her own many of the experiences of her six-year-old brother—even though the home training of the child was admirable.

This case has much in common with that of young Goethe. Obviously, however, it is not due to the child's reading, since the child was much too young to be thus influenced. It is rather a case in which the child had heard of certain experiences of its brother and then, having in all likelihood been powerfully thrilled by these, it had permitted its memory to be side-tracked by its stronger and better developed imagination.

The following is an interesting case reported by the wife of Professor Stern:

> We were speaking of H.'s little sewing basket when little E. playfully stated: "I got such a sewing basket from my Granny." E.'s brother and sister were astounded and so I suggested to them: "E. is only joking." But E. insisted: "No, no, no! Granny really and truly gave me one." Whereupon her brother curtly accused her: "Why, E. that's a fib!" . . . Finally I asked E. to show me the basket and now she became sulky and was on the verge of tears; and yet it was still some time before she would reply with a "No" to our questions whether or not she really had received such a basket.

Doubtless there are many parents who, without further analysis, would consider this instance of prevarication as something more than a mere pseudo-lie. However, while it is of course most difficult to evaluate the situation on the basis of cold words entirely divorced from underlying conditions, the actual motive for the child's untruth seems most innocent. There is here an entire lack of any purpose to achieve something by means of deception. This is again a situation in which the child is merely playing with reality.

Many apparent lies are due to the fact that the child's speech is still in a more or less half-developed state. This is especially true, of course, of younger children, who, in order to express their affective attitude, frequently employ terms of speech which the adult uses solely to affirm or deny facts. The little two-and-a-half-year-old boy who had been ill and who had formed the habit of crying "Ouch!" whenever anybody touched him did not really mean to give the impression that he was in pain, but merely wished to convey the information that he wanted to be left in peace. The word "no," which to the adult represents an unequivocal denial, is often employed by the child in an endeavor to get rid of something unpleasant. Thus, the three-year-old youngster who had struck his little sister so that she cried, when later reminded of the fact that he had hurt her, vehemently cried out: "No, no, no!" This negation, however, is not to be taken as a lie. Rather does it represent the lad's wish to hear no more about his misdeed. It is merely the child's crude way of saying: "I'm sorry; please don't remind me about it any more."

It has already been suggested that a great source of misstatement on the part of children is due to the questions to which they are frequently subjected. Since at the outset the child's answers are not a conscious attempt at deception such childish misstatements should be classified as pseudo rather than as real lies. The danger of these unconscious misstatements inheres not in themselves but in the fact that they may eventually lead to conscious and deliberate falsehood. The moral to be observed is that one should ask no more questions of children than are absolutely necessary and that one should formulate these as carefully as possible. The following incident

reported in a number of European dailies more than a score of years ago illustrates in very definite manner the important rôle assumed by the question:

> One day a little boy disappeared mysteriously. One of his comrades reported to the boy's distraught parents that the 13-year-old X had told him that he had been swimming with the missing boy and that he (X) had pushed the lad into the water when the latter wasn't expecting it and that consequently he had drowned. [Note: This statement of X may actually have been true in part or it may have been entirely an imaginative invention.] Cross-questioned by the missing lad's father—who naturally was under great emotional strain—X became more or less intimidated and admitted everything he had previously reported. Finally the case was dragged into the courts and here again X, when questioned with regard to specific details of the alleged incident, pointed out everything requested with sharp precision. When, however, X was approached with kindness so that his confidence was stimulated, he contradicted almost all his previous testimony. In a word, then, X could no longer differentiate between actual fact and that which had been suggested to his receptive juvenile mind in the form of dubious interrogation. After several days the lost boy returned and thus what might otherwise have ended in tragedy terminated more fortunately.

This case is typical and it is only one in many. Both the child and the questioner were acting in good faith. The questioner's interrogations, however, instead of arriving at truth only succeeded in befuddling the child's mind and in producing a most confused conglomeration of responses. It is in view of these facts that several of the larger cities in Germany are to-day making serious attempts to require the presence of a professional psychologist in those cases where the testimony of children is to play more than an ordinary part.

IV

Definitions of "real" lies are as numerous as they are varied. Disregarding entirely the ethical aspect of a lie and interpreting our term merely on the basis of our previous discussion we shall define a real lie as being a *conscious* and *deliberate* attempt at deception for the *purpose* of achieving certain results. The fact that a real lie is a conscious misstatement as well as a deliberate one differentiates it from an accidental lapse of memory; the fact that there is a distinct purpose in view divorces it from the realm of imagination. This threefold nature of a real lie presupposes a fairly advanced state of psychic development. There must be sufficient judgment to discriminate between fact and fable and to dissimulate a lie so well as to make it appear as truth. Then, also, the power of will must be sufficiently strong to arrange and classify the various actions necessary for the deception and for their carrying out. Those psychologists, therefore, who questioned whether a child below the age of four ever told a real lie were not so pedantic as might ordinarily be assumed. The majority of real lies owe their origin to pathological rather than to any other causes. Bearing in mind that what seems to be a lie is often not a lie at all, one should not be surprised to find upon close analysis that the real lie among normal children is not such a common phenomenon as is popularly believed.

While the incidental elements may vary considerably, the majority of real lies is usually ascribable to fear. This cause and effect relationship between punishment and a lie is clearly resident in the following case:

> A three-year-old youngster once did some trivial thing which he should not have done. When his father asked him what he had done the boy said: "I don't know." But when the parent insisted on the correct answer, the lad, instead of giving it, said: "Don't hit me! Don't hit me!"

The most reprehensible form of a real lie is that which affects not only the child himself but which drags into its net absolutely innocent people. Such cases usually fringe on the borderland

of the pathological and fortunately are not so common among normal children. The following is a typical example:

> While the mother of a six-year-old youngster was out visiting, her boy in playing about the drawing room smashed the glass door of a valuable bookcase. When the mother returned, the lad rushed out to meet her and related a long and involved story of how the maid in cleaning the drawing room had poked the handle of her broom through the glass door of the bookcase. The youngster even went so far as to illustrate the precise way in which the maid had committed the alleged misdeed. Fortunately, however, the boy's mother happened to recall that the maid had given the drawing room a rather thorough cleaning that very morning. And yet it was not until after much persuasion *and the promise of no punishment* that the boy, very hesitant and much ashamed, finally admitted his lie.

Somewhat similar to the foregoing incident but not quite so involved is the following, reported by Paulo Lombroso in 1905:

> A three-year-old girl, while visiting a friend of her mother, broke her little doll which she had taken along. The woman whom she was visiting tried to talk the little child out of its fear that it would be punished at home for its broken doll. Arriving at home, the child told the story that the woman had broken the doll—convinced no doubt that the woman, in order to safeguard it from punishment, would also assume the guilt.

Not all lies, however, trace their genesis to the fear of punishment. A small minority results from other causes. Thus, a child will sometimes attempt deception in order to avoid something it dislikes exceedingly, or on the other hand, to gain something it likes very much. To avoid doing its homework a child may say that none was assigned or that the work has already been done. These same statements might also be offered by the child that is anxious to go out and join its fellows in play. To get out of eating something it does not particularly relish a child will feign illness. The writer is acquainted with a certain youngster possessing a pronounced aversion for rice. Whenever this farinaceous hobgoblin is served, this particular lad will eat a mouthful or two and then suddenly drop his fork and writhe in terrible agony. Yet whenever rice is served in the form of pudding, strange to relate, the horrible "pains" never appear.

A fairly large number of real lies are prompted by some form of selfishness.

> Every game [says G. Stanley Hall], especially every exciting one, has its own temptation to cheat; and long records of miscounts in tallies, moving balls in croquet, crying out "no play" or "no fair" at critical moments to divert impending defeat, false claims made to umpires, and scores of others show how unscrupulous the all-constraining passion to excel often renders even young children.

It is of course hardly necessary to comment that this particular form of fabrication is not at all monopolized by children; and that their elders are sometimes rather prone to participate therein.

Somewhat akin to selfishness as a cause of the real lie are the child's love of showing off and its desire to appear big and important. Commonly known as bluff these manifestations of self-glorification are at times quite innocent. Frequently, as in the cases cited of Goethe and Gottfried Keller, they are due to an exuberant childish imagination. Unless the child aims to achieve a definite purpose by its deception it is not—in the light of our definition—actually lying.

> An eleven-year-old girl heard its school companions speaking a great deal about tours, costly equipment, etc. Since its own parents were poor and it could never hope for such things, and since it did not wish to appear inferior to its companions, the child fabricated a series of lies—so carefully, however—that no one was able to detect the untruth. The kernel of this untruth centered about a prominent man with whom the father of the child was acquainted in a business way. According to the stories of the child this gentleman now became a regular visitor of the child's home and thus every day it had some new incident

to relate, how he had been a guest at dinner, how her parents had given a large party in his honor, how he had drunk a toast to the health of her parents, etc. [Lombroso].

Unquestionably this form of fabrication approaches very closely to the pseudo-type of imaginative invention. The fact, however, that this child had a definite purpose in view, *viz.*, the simulation of parental wealth and social position, makes its lie more real than apparent.

The following form of child behavior is perhaps even a more definitive case of a real lie caused by the child's love of appearing important and better than its fellows:

A teacher of drawing had asked her young pupils whether one of them would not be able to bring in some flowers to be used as a model. A six-year-old youngster, remembering that his mother had received some flowers a short time ago, proudly volunteered that he would bring them to class. At home the child was informed that the desired flowers had been thrown out. In order not to appear foolish before its classmates the boy stole a pot of flowers from one of the neighbors and brought these to the teacher, attempting to pass them off as his mother's.

V

If the child lie were exclusively a matter of inheritance, if it were merely a question of instinct, or if, as is so commonly assumed, the juvenile lie were a necessary evil to be passed through like the measles or chicken-pox, then assuredly there would be little to gain in formulating methods of prevention. Since, however, the lies of children are the result not only of inheritance but of acquisition and environment as well, it may perhaps be prudent to pause for a moment to consider the short prescription which science has to offer in order to immunize the child against the lie.

Like most other diseases the lie is most susceptible to treatment before it has been given a chance to develop. Prevention, in other words, is better than cure. It is here that the popular fallacy which assumes that the child lie is a "necessary evil" imposes a burdensome handicap upon the unsuspecting parent, for, given even a tiny foothold, lies will quickly develop into deeply rooted habits, most difficult to eradicate. An occasional lapse into the realm of falsehood is of course not in itself a cause for alarm; neither, however, is it proof of the contention that lies in childhood are normal and usual. As a matter of fact psychological analysis has shown that potentially every child might be a George Washington. Practically, however, the attainment of such an ideal might be questioned since it would strip humanity of many of its most cherished illusions and delusions, which, though not always necessary, are on the other hand not absolutely undesirable.

The elements of the prophylactic attitude towards the child lie are epitomized briefly somewhat as follows. In the first place it is necessary for parents always to be truthful with children—even in trifles. It is especially advisable to eschew the conventional white lies which, as has been shown, have such a malevolent effect. Furthermore, the child should never be taught to lie. Those parents who ask their children to tell deliberate untruths are playing with dangerous toys. Over-severity in punishment should be avoided. At its best, it does little or no good; at its worst, it engenders fear, the arch-demon of humanity and one of the paramount causes of the juvenile lie. It is well to encourage the child's imagination, but with caution, since an over-stimulation of phantasy may blunt the child's sense of discrimination between the real and unreal. It is most important to remove from the child as many taboos as possible since these constitute an ever-ready source of transgression. By removing as many *don'ts* as possible we are destroying many embryonic falsehoods. As has been shown it is advisable to

avoid unnecessary questioning, since—unless the questioning is done well and properly—it may lead to unconscious slips in memory, or by dint of suggestion it may force misstatements upon the child, and eventually it might even lead to conscious and deliberate falsehood. Furthermore, it is exceedingly unwise to preach about the evils of falsehood to the immature child. Not only are we confronted here with the danger of magnifying every petty slip from truth, but we also face the possibility of suggesting many undesirable things to the child which it otherwise might not even dream of. Psychologists are well aware that the "don'ts" are frequently the very suggestion leading to the actual violation of a prohibited action. Most important of all is the need of securing the child's confidence and cooperation in the battle against untruth. As Dr. Stern has suggested, "A child who has been taught by its parents the meaning of self-conquest in everything, who has learned to control his anger, to give up pleasure for the sake of others, to own to a fault, even indeed to find a certain satisfaction in self-conquest, will master, too, any temptation to lying ways."

A TRIP TO SANTO DOMINGO

By Professor FRANK D. KERN

PENNSYLVANIA STATE COLLEGE

HISTORICALLY Santo Domingo is an interesting place and well known. All good students of American history remember that the island was discovered by Columbus on his first voyage to the new world in 1492, that he named the island Hispaniola and that the first European settlement in the new world was made here by the Spanish. It is the second largest of the West Indian islands, being exceeded in size only by Cuba. The Dominican Republic occupies the eastern part of the island and the Republic of Haiti the western part. The Republica Dominicana (official) possesses about twice the area of Haiti, and is larger than Belgium, Denmark or Switzerland, or Connecticut, New Jersey or Massachusetts.

Scientifically, Santo Domingo is also an interesting place but not so well known. With R. A. Toro, of the Insular Experiment Station of Porto Rico, I visited the Dominican Republic during

A STREET SCENE IN SAN JUAN
THE HOUSES ARE TYPICAL OF MANY VILLAGES.

A HIGHWAY THROUGH A DESERT REGION
THE AUTOMOBILE HAS A FLAT TIRE CAUSED BY A CACTUS SPINE.

March, 1926, making a study of the plant quarantine situation, observing the plant diseases and collecting fungous parasites of both cultivated and wild plants. I was especially interested in the rusts or Uredinales and my colleague in the black fungi or Pyrenomycetes. While we kept to the field as much as feasible, industriously and minutely examining all vegetation in quest of fungi, we found some general observations possible.

In Santo Domingo city, which is always referred to by Dominicans as "la Capital," we were shown the ruins of the Columbus house, a massive stone house with thick colored walls now in a bad state of repair. We also saw the reputed Tomb of Columbus in the cathedral. The tomb is elaborate and beautiful and in its present form dates from 1892, the four hundredth anniversary of the discovery of America. The cathedral, a fine old structure in Spanish Renaissance style, dates from 1512 and is doubtless the oldest church edifice in the Americas. They have post cards depicting the ceiba tree where Columbus is said to have tied his boat, but they do not show the tree, explaining that it no longer remains. Portions of the ancient walls, with their bastions and gates, characteristic of the Spanish colonial towns of the sixteenth century, are still to be seen in this interesting old city.

Santo Domingo enjoys the same mild tropical climate characteristic of the other large islands of the Antilles. Considerable variations in temperature are caused by the differences in the meteorological conditions and altitude. We

heard a good deal about the cold which prevails at night in the high mountain valley of Constanza. There is no doubt that freezing temperatures often prevail here during the nights of January and February. At the coast in March the days were hot, but the nights were cool and delightful. In the humid sections of the eastern part rains are usually frequent and heavy from May to November. This year they kept up well into January. During the rest of the year the rainfall is scanty. In the western and southwestern sections rain is very scarce at all times, and the vegetation is typically xerophytic, in great contrast to the luxuriant growths of the humid regions.

An excellent highway extends northeast from the capital, on the southern coast, to Monte Cristi on the northern coast. We traveled on this road from the capital to Santiago, the second city of importance in the republic. The surface of the roadbed could be improved in many places, but the survey and grading of the highway are beyond criticism. In passing along this region for an extent of more than one hundred and ten miles one sees great fertile areas that have not yet been agriculturally improved. Further back are other regions, not yet opened up by highways, which can be transformed into productive areas. The successful cane, coffee, cacao or tobacco plantations, occupying only a small percentage of the suitable and available areas, are the best indications of future possibilities. Many tropical fruits grow here with minimum attention. Practically no commercial production of citrus has been attempted.

PORTION OF THE OLD CITY WALL ABOUT SANTO DOMINGO

A PART OF ONE OF THE PRINCIPAL STREETS MAY BE SEEN THROUGH THE GATEWAY.

THE CITY OF SANTO DOMINGO, DOMINICAN REPUBLIC

RUINS OF THE COLUMBUS HOUSE, SANTO DOMINGO CITY

PARQUE INDEPENDENCIA IN SANTO DOMINGO

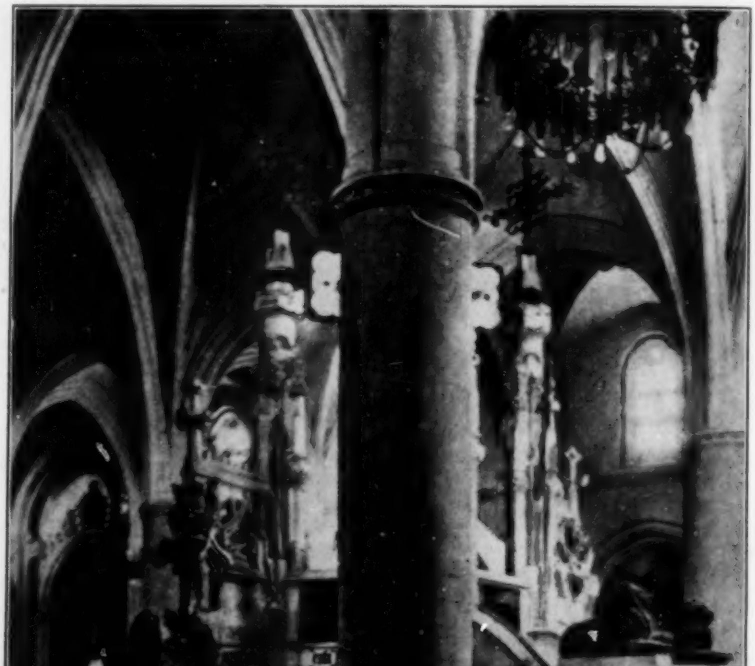
From Santiago the main highway continues to the northwest to Monte Cristi. We were enroute to Puerto Plata, almost due north. A highway is now being constructed from Santiago to Puerto Plata. By special permission of the American engineer we were allowed to traverse a portion not yet open to the public. This allowed us to do some collecting in a region not otherwise accessible but did not help us in reaching Puerto Plata. To do this we were obliged to go by rail, a trip which was scenic and interesting, even if a bit rough and extremely slow. During the night of March 23 at Puerto Plata a shaking of the bed and banging of the shutters was sufficient to remind one that this is a region where earthquakes are likely to occur. We learned later that this same shock was felt in other of the islands and so did not harbor any special grudge against Puerto Plata.

Another trip on the highway which connects Santo Domingo with Port-au-Prince, Haiti, gave us a chance to see some of the dry sections. From the Nazao River westward through Azua and throughout the great valley of the San Juan desert-like conditions prevailed at this season of the year. A third trip eastward from the capital to San Pedro de Macoris and La Romana gave us an opportunity to see some of the finest cane land in the West Indies.

We found Santo Domingo a safe and pleasant place for botanizing. There may be some snakes there, but we did not run across any. The only reptiles we saw were lizards, mostly small or moderate-sized. These little fellows hold a place of their own in the estimation

of most travelers in the tropics. One would certainly miss them if they were suddenly to disappear. In some places in the mountains of Santo Domingo wild parrots are very numerous. A medium-sized green species, variegated with red, blue and yellow, is most common, although we saw a plain black form and also parrakeets.

There are still some fine forests in Santo Domingo. A forest growth here is often made of a considerable number of species adapted to the same conditions and thriving together. There is a great assortment in the sizes and forms of the individual trees, much variation in the density of the growth and no apparent uniformity in the association and distribution of species. Oftentimes it seems that the really valuable kinds are exceedingly scarce, forming a hopeless minority. In other instances a sin-



TOMB OF COLUMBUS,
INTERIOR OF THE OLD CATHEDRAL, SANTO DOMINGO CITY.

XEROPHYTIC VEGETATION
A VIEW SHOWING ITS DENSE AND GNARLED CHARACTER.

gle species may predominate. This is notably true in certain interior regions, where a species of pine (***Pinus occidentalis***) grows almost exclusively, forming great forests extending over the tops of the lower mountains. Sawmills are now in operation supplying pine lumber for local consumption. In La Vega one evening I was told by a lumberman how important a factor the moon is in lumbering operations. According to his statement lumber cut during the waning moon (*luna menguante*) remains sound and serviceable, while that cut during the new moon (*luna nueva*) is subject to attacks of insects and rots and soon becomes worthless. A belief in the effect of the moon on lumber is quite as well grounded here as its effect on planting and other agricultural operations is in other parts of the world. We did not take opportunity to make any investigations despite the urging of an American engineer, who was present and who insisted that the belief is more than a mere superstition. Other forest resources are mahogany, satinwood, lignum vitae, walnut and logwood.

Santo Domingo had its beginning in a Spanish colony and there is to-day a considerable population with Spanish blood, with a mixture of Negroes of Creole descent. There are also a number of whites of American and European origin and some Chinese who specialize in restaurants. Spanish is the official and predominating language, although English is heard everywhere. This was somewhat of a surprise. In Porto Rico one expects to find English spoken com-

monly, because it has been taught in the public schools for twenty-five years. In Santo Domingo it has not been taught, and yet in the transaction of business, on the streets, in the hotels and everywhere one may hear English spoken. My Porto Rican companion had a good deal of fun at my expense one time and since then claims that it is doubtful whether I understand English. Walking along a narrow street one day I saw indications of a rust on a small tree growing in a yard by a little house. While examining the leaves a woman opened a shutter and said something. Thinking she was likely to say something unpleasant and in Spanish about my being there I attempted to shift responsibility by calling to my friend to come and see what the woman was talking about. I then heard a voice saying, "Come and see what this woman is saying, I am speaking English." Of course I hastily offered an apology. She then told me that she was English. There are in Santo Domingo a good many colored people from the English islands and they all tell you that they are English. The woman just referred to informed me further that she would like to see her Queen Victoria. Needless to add, I did not offer any comment in this connection.

Another amusing incident happened one day when we were riding horseback in company with the mayordomo of the plantation where we were stopping at the time. My friend and the mayordomo were some little distance ahead of me. Suddenly I saw a man further down the

THE LARGER CACTI
WHICH ARE COMMON IN THE DRIER AREAS.

A TYPICAL VIEW OF THE INTERIOR OF THE ISLAND LOOKING TOWARD THE MOUNTAINS

road pointing a gun in our direction. I heard him say something to the two ahead of me but at the distance could not understand. I saw the two rein their horses quickly to the side and before I could act I heard a shot. It is true that for the moment I thought it might be something more serious than the shooting of a pigeon, but it is not true that I held up my hands and shouted "Una revolución," as my companion relates.

Dominican money consists of coins only. The unit is the "*peso dominicano,*" a large coin about the size of a silver dollar but worth only twenty cents. United States money is the standard of value and can usually be had in change. One soon tries to avoid the native coins, which run into such bulk, representing as they do only one fifth the value of our corresponding pieces.

Observations and studies were made of the diseases of economic crops, especially from the point of view of the plant quarantine situation in Porto Rico. No diseases were found on any of the crop plants which do not already exist in Porto Rico. Some of the staple crops were found to be particularly free from serious diseases in Santo Domingo. The coffee plantations visited were notably free from diseases. Cacao is an important crop and was also notably clean. Sugar cane, which is the major crop, was in most places very seriously affected with mosaic. In some places certain varieties showed 100 per cent. infection. We were convinced that sufficient attention had not been given by cane growers to efforts to control this disease. They

are apparently beginning to give attention to the matter of clean seeds and resistant varieties. Some other diseases of cane appeared to be less prevalent than in Porto Rico. The chamaluco variety of banana is disappearing because of its susceptibility to the wilt disease. However, other varieties of banana are more resistant and they are cultivated more extensively.

Approximately four hundred collections of fungi were made and have been preserved for further study and investigation. It is expected that these studies will yield some interesting information for comparison with the better known regions of Porto Rico, the Virgin Islands, Cuba, Jamaica and Central America. An expedition undertaken during the rainy season of the so-called summer months would be likely to be productive of better results, even though it would be beset with more difficulties in collecting. In our work we were very generously and effectively aided by the Secretario de Estado de Agricultura e Inmigración, the Director de la Estación Agronómica y Colegio de Agricultura, by other civil and military authorities and by numerous private citizens.

Before going to Santo Domingo we were told by some good friends that it was a land where people rode on the highways astride of oxen, that the movie films had only Spanish legends, and that the people smoked only big black cigars which were strong and expensive. On the contrary, we found that they ride burros, that the movies have English as well as Spanish legends and that most of the natives smoke pipes, although good moderate priced cigars are available. Our experience leads us to conclude that a country, as well as a man, sometimes may be unintentionally maligned by perfectly well-meaning persons. We were glad we had the opportunity to investigate for ourselves.

THE STORY OF THE STONES IN THE DOMINION PARLIAMENT BUILDING

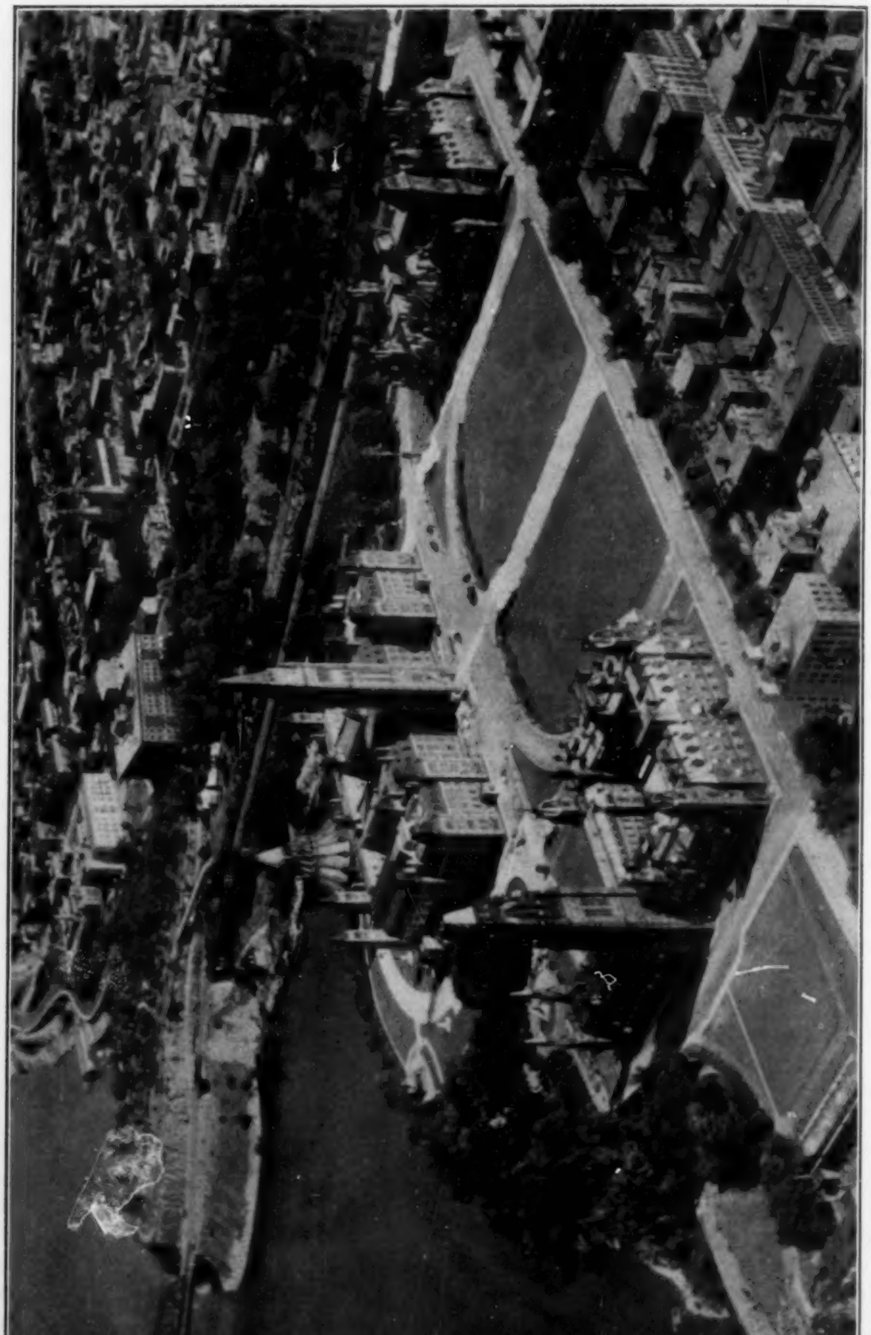
By Dr. E. M. KINDLE
GEOLOGICAL SURVEY OF CANADA, OTTAWA

THE new Parliament building in Ottawa displays in its beautiful Gothic lines good examples of some of Canada's best known building stones. The fossils in some of these record singularly well certain parts of Canada's prehuman history. The walls and spires of this splendid building exhibit to the best advantage the beauty of Canadian building stones from provinces as far apart as Quebec and Manitoba. The creamy mottled limestone of Manitoba, with its fossils sectioned in various directions by the stone cutter, and the green serpentine from southern Quebec may be seen in the corridors of the building, while the outer walls are constructed of Cambrian sandstone from quarries a few miles to the southwest of Ottawa. Inside the base of the Memorial Peace Tower Flemish marbles have been used. Certain combinations of serpentine and marble furnish the verde-antique marbles which are also represented in the interior of the building; but it is with the story of the Manitoba limestone and the much older Cambrian sandstone clearly written in hieroglyphics quite legible to the paleontologist that we are here concerned.

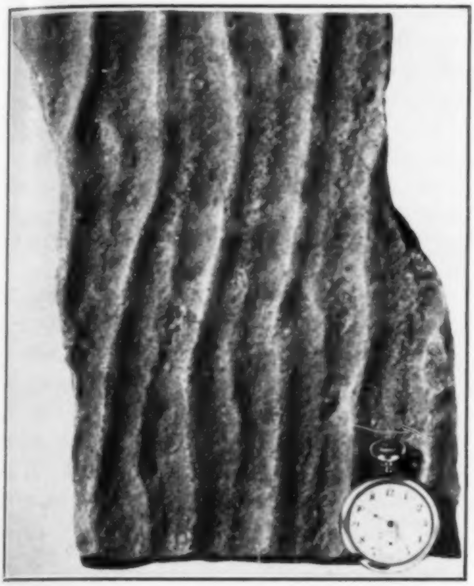
SIGNIFICANCE OF THE CAMBRIAN SANDSTONE

Very considerable fragments of certain chapters of the great stone book, from whose pages the geologist reads the story of the world, have been assembled in the walls of this building. The oldest and most extensively used of these fragments of the past are the sandstone blocks of the outer walls. These came from the Potsdam sandstone of the Ottawa valley, which is a formation of Cambrian age. Thus quite unintentionally the architects have invited visitors with the enquiring type of mind to make a little journey in time.

The formation of the Potsdam sandstone is so far back in the geological ages that the mental journey essential to restoring a picture of Cambrian times in the Ottawa valley should be made in stages. The depression of the Ottawa and St. Lawrence valleys, which some 15,000 years ago submerged Parliament hill under 200 feet of sea-water, seems remote in time as compared with recorded human history. But the long slow creep of the northern ice cap, which for unnumbered thousands of years moved southwards over the continent to the middle of the United States and finally retreated as slowly as it came, preceded this great westerly incursion of the Gulf of St. Lawrence. Even the coming of the continental ice cap more than 100,000 years ago the geologist thinks of as a relatively recent event, for the great ice sheet found the Ottawa and St. Lawrence valleys in their broader features much as they are to-day. It is only when we go back to such an event as the birth of the Gulf of Mexico and the coincident appearance above the sea of the southeastern corner of the continent which added Florida and the southern half of the Gulf states to North America that we begin to get the geological perspective essential to considering the earlier reaches of geological time.



THE DOMINION PARLIAMENT BUILDING FROM THE AIR



OSCILLATION OR WAVE-MADE RIPPLE-MARK WITH SMALL MEDIAN RIDGES BETWEEN MUCH STRONGER ANGULAR RIDGES ON CAMBRIAN SANDSTONE, HAMMOND, N. Y.

Three million years ago in Pre-Florida or Eocene times the present site of Chicago was 575 miles nearer the sea to the south of it than at present. The head of the Mississippi Gulf, forerunner of the Gulf of Mexico, was then near the site of Cairo, Illinois. This phase of American geography coincides with the dawn of the stage of earth history which geologists call the Cenozoic or the era of modern life. Near relatives of modern plants and animals were then in existence, including the fox-like progenitor of the modern horse.

But the outer walls of the Parliament building carry us back through the deeps of time to the early Paleozoic when no animal with a backbone had appeared on the earth. Plants more highly developed than algae did not then exist. Neither plants nor animals had in Cambrian times become fitted to live on the land. Not till ages later had plant life developed to such a stage that its accumulated remains became sufficiently abundant and of suitable kinds to produce the materials for beds of coal. The paleontologist is therefore able to predict with confidence that coal will not be found in rocks containing Cambrian, Ordovician or Silurian fossils. Such predictions are entitled to the same confidence which is generally accorded the astronomer's announcement of an eclipse of the sun. Unfortunately for the hapless investor in bogus coal prospects the advice of the paleontologist is not sought as frequently as it should be. This may result from the fact that the general principles underlying astronomy are better understood than are those which form the basis of paleontology.

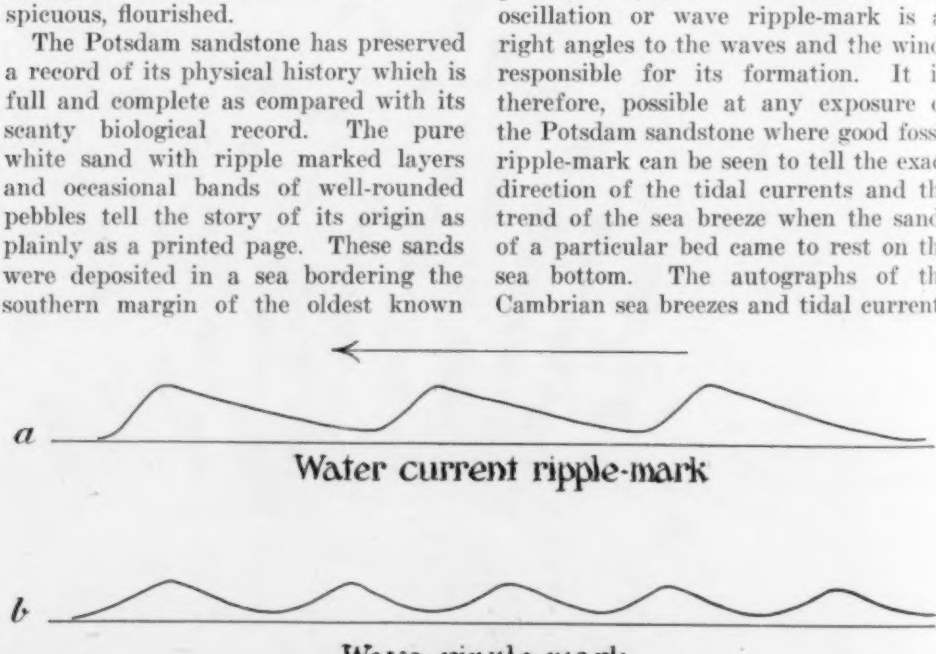
It is a fundamental principle of geological biology that the several kinds of animals and plants die and eventually pass off the stage of time to be followed by other different but related kinds. Just as the individual animal has a lifetime of ten or one hundred years, so the species has its life span of 10,000 or 100,000 years or more and disappears from the living world but leaves the record of its life—when it came and when it went—in the rocks. There is one case, however, which comes near being an exception to this law. *Lingula,* a simply constructed little shell of the present seas, is one of the forms of life which time forgot or almost failed to change, for in the sandstone from which the Parliament building is chiefly constructed there is a small shell called *Lingulepis* which is almost but not quite the same as the living Lingula. The occurrence here of this very ancient ancestor of the modern *Lingula,* which has defied successfully the bounds of time set for nearly all other types of life, lends a peculiar geological interest to the Cambrian sandstone in the Parliament building.

These sandstones contain but little evidence of the life of the early geological period which they represent beyond these linguloid shells and broad trails, which remind one of an automobile track. These trails were made by a creature still unknown. Good examples of them may be seen in the National Museum at Ottawa, labelled *Climactichnites wilsoni* Logan.

It must not be inferred because the known fossils of the Potsdam sandstone are limited to a Lingula-like shell and the trail of a huge but unknown mollusc that life was scarce in the Cambrian sea, which this sandstone represents. It is well known to naturalists that the sandy bottoms of the present seas are comparatively lifeless, and the shifting sands of the Cambrian seas were, as the Potsdam sandstone indicates, equally unfavorable to life. Where other types of bottom prevailed a host of strange creatures, among which trilobites were most conspicuous, flourished.

The Potsdam sandstone has preserved a record of its physical history which is full and complete as compared with its scanty biological record. The pure white sand with ripple marked layers and occasional bands of well-rounded pebbles tell the story of its origin as plainly as a printed page. These sands were deposited in a sea bordering the southern margin of the oldest known land in Canada, which occupied approximately the position of the Laurentian highlands or the Canadian shield. The sand of this formation came from the decay of the granites and gneisses of this old V-shaped land mass which now holds Hudson Bay in its arms and reached the sea by rivers which are known only by the sandstone formation which they gave to the young continent.

The fossil ripple marks found at various levels in the Potsdam sandstone have recorded both the waves and the currents which were engaged in the work of spreading the sands over the old Cambrian sea bottoms. Waves and currents make distinct types of ripple-mark—the one symmetrical, the other asymmetrical. Both types are found well developed in the Potsdam sandstone. Current or asymmetrical ripple-mark always trends at right angles to the direction of the water current which produced it, and the direction of the oscillation or wave ripple-mark is at right angles to the waves and the winds responsible for its formation. It is, therefore, possible at any exposure of the Potsdam sandstone where good fossil ripple-mark can be seen to tell the exact direction of the tidal currents and the trend of the sea breeze when the sands of a particular bed came to rest on the sea bottom. The autographs of the Cambrian sea breezes and tidal currents



DIAGRAMMATIC CROSS SECTIONS OF WATER CURRENT (*a*) AND WAVE MADE (*b*) RIPPLE-MARK.

inscribed on the Potsdam sandstone more than thirty million years ago are just as legible as those now being inscribed on the sandy beaches of the Atlantic coast.

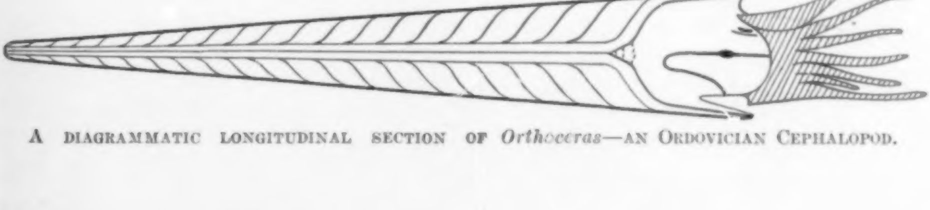
The sands which became the Potsdam sandstone when consolidated were a near-shore deposit of a Cambrian sea which stretched across northern New York state into southeastern Ontario. The argillaceous and deeper water sediments of other facies of the same sea bottom and their richer fauna are probably all buried under younger rocks, but even where Cambrian life was most luxuriantly developed it gave no hint of the coral and cephalopod life which followed it in the next geological era. These we find abundantly in the Manitoba limestone.

The Manitoba Coral Seas

Far more novel in appearance than any of the fantastic gargoyles about the Parliament building are the fossil molluscs which adorn some of the blocks of Manitoba limestone in the corridors. Many of these fossil animals are so remote from modern forms of life or structure as to be scarcely reminiscent of them. The visitor who is curious about the ancient life of this continent must go to the National Museum to see Canadian dinosaurs, but sections of the no less strange Manitoba cephalopods or devil fish, which disported themselves some thirty million years ago in the Ordovician seas where now the Manitoba wheat fields stretch away to the horizon, may be seen in the corridors of the Parliament building. These great shell fish with their many partitioned tubular shells were progenitors of the modern pearly nautilus.

Oliver Wendell Holmes' poem "The Chambered Nautilus" has made familiar a plan of structure which begins with the venerable Cephalopod dynasty of early Ordovician times. Their living descendants and relatives include besides the sea squid and the Pearly Nautilus, the Paper Nautilus which was once believed to come to the surface at times and "spread to the wafting breeze a two-fold sail." This pleasing fancy of the days of Aristotle has however been dispelled by the naturalists. The Nautilus is now known to swim rapidly by projecting a current of water through a funnel-like organ. The Ordovician cephalopods doubtless swam in the same way making "headway back foremost."

Sections of some of the corals which lived in the ancient seas of Manitoba may also be seen in the Parliament building corridors, together with brachiopods and various other fossils which date the stone blocks holding them back many millions of years before the time of either men or Parliaments. One may speculate but can never know about the many other strange creatures without hard parts capable of fossilization which were probably contemporaries of the corals and the cephalopods. Some creatures of our present seas without any hard parts which can leave a record after death are in many cases among the most curious of modern animals. Some of the jelly fishes glow at night with a soft blue light and we know by one fortunate discovery made by Dr. C. D. Walcott that this type of animal appeared as far back as the Cambrian. Other soft-



A diagrammatic longitudinal section of *Orthoceras*—an Ordovician Cephalopod.

bodied creatures like the tunicate colony called *Pyrosoma* emit when stimulated a bright light, and one naturalist records writing his name with his finger on the side of a pyrosoma at night which came out a few seconds later in letters of fire. It is probable that the Ordovician sea of Manitoba possessed like modern seas many phosphorescent animals. The Manitoba sea may have often shown at night waves flashing with a weird dull blue light. They may even have rivalled Professor Hickson's description of a dark night on the Banda seas when "the water is often like a huge expanse of pale blue smoke studded with diamonds and other lustrous gems." Whether or not phosphorescent animals lent their magical colors to the Ordovician seas which produced the mottled limestone of Manitoba, the corals themselves must have supplied, as modern corals do, a rich variety of colors. Dull brown and green tones are characteristic of the coral reefs of the present subtropical seas, but these are often varied with bright violet growing points in the branches of the Madrepores. Orange or red fan corals, bright brick red sponges, emerald green organ-pipe corals and scores of other forms of life also add their contribution to the riot of color which accompanies the coral reef of to-day. Since most modern corals after the decay of their soft parts give no hint of their colors in life, we can not expect the Ordovician fossil corals to supply any evidence of their living colors except by analogy. But it seems a safe inference that the corals which furnished much of the material of the Manitoba limestone contributed to the shallow Ordovician seas of Manitoba a wealth of color and beauty in which green, brown and yellow were prominent.

In the rocks which underlie the prairies of western Manitoba, Saskatchewan and Alberta is recorded the story, much too long for these pages, which Canadian geologists have deciphered of the transformation of the old Ordovician coral seas of Manitoba successively into the Silurian, Devonian and still later into the early Cretaceous seas with their ammonites. Later yet came the marshes and sea-side lagoons of western Canada with their dinosaurs, but this was long before the birth of Florida and the Gulf of Mexico.

The Cultural Aspect of Geology

After making the little journey in time which the stones of the Parliament building suggests, the visitor should be able to pursue with a more discerning eye the little journeys into politics and human history which this building may also inspire him to undertake.

In place of the finished world of a few generations ago we now recognize a constantly changing world which has been tenanted by an endless succession of plants and animals, each unlike and a little in advance of those which preceded it. The geography of to-day we now know to be no more permanent than the cloud forms of yesterday. Familiarity with geological concepts has contributed enormously to mobility of mind and broad intellectual hospitality. The man who can visualize clearly the physical geography of Canada as it has been in the remote past is prepared to comprehend as well as to meet and direct the great changes incident to the evolution of the social, economic, and political world in a way that his brother who still lives in the finished world of yesterday can not.

A MOUNTAIN SOLAR OBSERVATORY

By Dr. C. G. ABBOT
SMITHSONIAN INSTITUTION

Does the sun vary in its output of rays available to heat the earth? If it does, the weather must vary in some way depending thereon. Hitherto meteorologists have not used this element in making their predictions because the necessary solar studies have not been available. For the past eight years the Smithsonian Institution has been endeavoring to supply this lack by maintaining stations in Chile and in the southwestern United States, where almost daily measurements are being made of solar heating.

It is not the variations of sun-heat as found at the earth's surface that are in question, for these depend on the haziness and humidity of the atmosphere much more than on real solar changes. The measurements must be made in such a way as to eliminate atmospheric losses and to give the true value of solar radiation as it is in free space at the earth's mean solar distance. This quantity is usually called the solar constant of radiation, and we shall call it so in this article.

The average value of the solar constant for the past twenty years appears to be 1.94 calories of heat per square centimeter per minute. Fluctuations from this mean value as great as 3 or 4 per cent. in both directions, or a range of 6 or 8 per cent. seem to be found. These changes are of two types. One runs over long intervals and is definitely associated with the sunspot activity. Apparently the solar constant averages 2 or 3 per cent. higher at times of sunspot maximum, that is to say, at intervals of approximately eleven years. Again, there seem to occur short interval changes running their course in a few days or weeks. Often these seem associated with the central passage with solar rotation of sunspot groups over the solar disk. Low solar constant values occur at such times for several days.

Hitherto, the average accidental difference between the daily measurements of the two Smithsonian stations, situated four thousand miles apart, in the United States and Chile, has been about 0.5 per cent. But on a good many days the differences are considerably larger, and on many days one or both stations fail to observe because clouds interfere.

This matter of the variation of the sun concerns the whole world. In order to make the determinations of the solar changes more complete and accurate, the National Geographic Society has given to the writer a grant of $55,000 to use for three purposes: (1) To select the best site in the eastern hemisphere for locating a cooperating solar observatory; (2) to procure the necessary equipment, including the construction of buildings, roads and apparatus; (3) to carry on daily solar constant work for a period of about four years.

There are several determining considerations. An isolated mountain site in a desert country is needful in order to diminish effects of dust, haze, smoke and cloudiness. Easy communication is required for installing and maintaining the station and for securing daily telegraphic reports of results. Governmental conditions must be stable and firm enough so that the observers need not fear assassination and confiscation. Many minor considerations add to the difficulty of a choice of site.

After consulting available meteorological data, conditions seemed most promising in Algeria, Baluchistan and Southwest Africa. Accompanied by Mrs. Abbot, I left Washington on October 30, 1925, and journeyed by way of England, France, Algeria, Egypt, India, Baluchistan, South and Southwest Africa, and arrived at home on April 26. We were gone almost six months and traveled nearly thirty thousand miles.

In Algeria, the Djebel Mekter, about seven thousand feet high, and four miles south of the French military post of Ain Sefra, was examined. There is a stone building on its summit formerly used as a heliograph station, and which might have served as both dwelling and observatory. A well-graded rocky road leads up to it.

The impressions of a French officer, Captain Navarre, who had been stationed at Ain Sefra for five years accorded well with recorded daily observations kept by a soldier as to the cloudiness of the region. It seemed probable that during January, February and March many days would be lost, leaving a minimum of at least ten days per month favorable. During the remaining nine months, upwards of twenty nearly cloudless days per month could be confidently expected.

A local contractor was ready to repair the building and the French government and military authorities were cordial to the proposal of establishing the observatory there. However, a still more favorable condition as to cloudiness was hoped for.

A few days were spent in Egypt, and inquiries made of several English scientific men at Cairo as to the possibilities of finding a good location in that sunny country. It appears, however, that mountains high enough to avoid dust and haze are inaccessible in Egyptian territory.

Arrived in India, we were hospitably entertained at Delhi, and provided with recommendations to the authorities in Quetta, Baluchistan. There we were most kindly treated and assisted, especially by Colonel and Mrs. Trench, of the Political Agency, and by Colonel Barker, of the Royal Engineers. Although Baluchistan is far from being a calm, humdrum country, it was decided that the observatory might be located with considerable safety on Khojak Peak, seven thousand five hundred feet high, and about ten miles from the Afghan border.

As the military rule requires that autos on the road to the peak must carry a loaded rifle, and not less than two persons besides the driver skilled in using it, I was not surprised to be informed that the observers would not be permitted to reside at the peak, but must be quartered at Shelabagh, a garrison town three miles east. Two native soldiers would be required to watch the observatory, and a third to ride to and fro daily with the observers. Owing to the caste system, cooks will not sweep, nor valets serve, so that several servants besides the soldiers would be needed to keep up face in a country where no white man is supposed to lift a handkerchief.

Thus quite a staff of dependents must be attached, and this with large expenses associated with the immense distance from Washington, and the costliness of construction and supplies, and the uncertainty of relief from customs duties, tended, with the separation of dwelling quarters, to counterbalance the advantages of an apparently excellently clear and cloudless sky.

Arrived in South Africa, a stay of ten days in Johannesburg was made while official connections were being established and inquiries made. Dr. Innes, of the Union Observatory, and Dr. Alden, of the Yale Observatory, as well as Mr. Donald, the United States consul, and the vice consul, Mr. Hall, all exerted themselves to aid and entertain us.

Valuable information as to conditions in Southwest Africa was given by Dr. Reuning, formerly geologist for the German government of Southwest Africa.

Arriving at the capital, Windhoek, Colonel Venning, director of posts and telegraphs for Southwest Africa, introduced me to other officials. It was soon decided that the best location is the Brukkaros Mountain (Lon. 17° 48′ E., Lat. 25° 52′ S. Alt. 5,202 feet. General level of the plateau surrounding, 3,000 feet).

This mountain lies near Berseba, the principal town of the Hottentot reservation. An affirmative vote of the Hottentots was necessary to permit its occupation. The railway division town of Keetmanshoop, about sixty miles to the south, will be the point of supply.

The Brukkaros is a very small cup-shaped mountain rising precipitously two thousand feet above the plateau which extends almost level for fifty miles in every direction. The average rainfall there is three and one half inches, occurring one third in February, one third in March and the balance scattering.

It is very favorable to the cooperation of this station with our other two that December at Brukkaros is fine and January but little cloudy. These are the worst months at our other stations. I was near the Brukkaros for twelve days in the height of the rainy season. Of these the forenoons of eleven days were excellent for our observations. There is great hope that upwards of 90 per cent. of all days of the year will be available there.

The clearness of the atmosphere is very fine. One notes almost no perceptible haziness in looking out over the plateau to the horizon. Even as seen from low-lying stations, the stars go down without becoming dim and disappear suddenly as if occulted, while still retaining their brilliance. On the Brukkaros the sky was of a deep blue right up to the edge of the sun.

During my stay in the neighborhood there were no heavy winds, hardly, indeed, the slightest breeze, but I was told that there were occasionally in winter some days of strong wind. Yet the desert in that neighborhood has so coarse and stony a texture that sand drifts are not to be seen.

Our proposed observatory site is situated near the southwestern summit, but inside the rim of the cup-shaped mountain, so that the configuration itself will tend to reduce the force of such winds as may sweep the plateau. The observatory rooms, as in our other stations, will lie in a horizontal tunnel about thirty-five feet deep in the rock. The sun-beam is reflected in with a coelostat carrying stellite mirrors which never tarnish.

Within the tunnel is the spectroscope and the bolometer-galvanometer combination, capable of observing and automatically recording the heat of the spectrum rays to the millionth of a degree rise of temperature. Outside are the pyrheliometers and pyranometer for measuring directly the heat of the sun and of a small ring of sky immediately surrounding the sun. With the findings of the three types of instruments combined, two observers may determine the solar constant five times independently in a single morning of observation and may get the results computed by early afternoon.

The station was begun in April under the supervision of Mr. A. Dryden, inspector of public works for the Southwest African Government. Apparatus had been procured in Washington, and it was planned to send out the expedition in early autumn under Mr. W. H. Hoover, director, and Mr. F. A. Greeley, assistant. Observing could begin within a month of arrival on the ground.

Meteorologically, the location seems superb. It is very isolated. No neighbors are nearer than the Hottentot village of Berseba, seven miles away, and there are but two white people in Berseba. The supply town is Keetmanshoop, sixty miles or three hours distant by auto. This is a pleasant place, a railway division point, with bank, hospital, churches, clubs, hotels, schools and general stores.

Provisions must all be brought by auto and mule-pack. Water sufficient, but not plentiful, can be had on the mountain itself, though nearby barren, tufted grass sufficient to maintain much game covers the desert. What with occasional visits to town, books, games, radio, music, hunting and interesting work, the observers hope to be contented to stick out their three-year terms. Of course the opportunity to see the world counts with them in going to this remote corner.

The trail, the tunnel, living quarters, garage and two cemented reservoirs were completed by Mr. Dryden early in September. The expedition landed at Capetown on September 13. Providing all has gone well, observing should have commenced on the Brukkaros by November 1, 1926.

Cooperative observing by three desert-mountain solar-radiation observatories, under one management, is now assured for several years. Yet the next generation will be at loss as much as we are, to answer the question whether solar variation is an important element of weather, unless financial support sufficient to continue the Smithsonian measurements in future years quickly becomes available.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES[1]

By Professor A. E. KENNELLY

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We all know how simple is our system of money based on dollars and cents. We realize that its simplicity depends upon the ten-to-one or decimal relation of its parts. There are ten mills to a cent, ten cents to a dime and ten dimes to a dollar. All sums of money are thus expressed in dollars with decimal steps.

Unlike our money, our system of weights and measures is complicated and difficult. The ten tables taught in our schools comprise about fifty different units, not decimally connected. Very few people can say these tables from memory, without a mistake. The tables taught in English schools comprise about sixty units. Most of the corresponding American and English units are the same; yet there are fourteen that have different meanings. These are the hundredweight and ton, which are long in England but usually short with us, the pint, quart, peck and bushel in dry measure, the minim, dram and ounce of apothecaries' measure, likewise the gill, pint, quart, gallon and barrel in liquid measure, all of which are respectively about 20 per cent. larger in Canada and the British Empire than in the United States. We still keep the old wine gallon of Queen Anne; while the British changed about one hundred years ago to the imperial gallon. All these fourteen units are ambiguous, and they frequently lead to misunderstandings.

In order to clear up similar complications, the French introduced, about the year 1800, a new system, which they called the metric system because it was based on a certain new standard yard, called the meter. The meter is only roughly a yard. It is about 10 per cent. longer than our yard. They applied the ten-to-one or decimal steps to this meter, just as in our decimal money system. The metric system came into general use in France about ninety years ago. It was found to be definite and easy. They called one thousand meters a kilometer, from the Greek word for a thousand, and this serves for the measure of great lengths. A kilometer is thus one thousand world yards, or very closely one thousand one hundred of our yards. One may travel all over continental Europe, by either highway or railroad, and find the distances marked off in kilometers. During the great war, two millions of our young men visited France, and so came into contact with the use of the metric system. Since their return to the United States, there has been a distinct increase of popular interest in the metric system. About twenty-five years ago, the advocates of this system were mainly scientists; but since the war, mainly business men. There are only three main units in the metric system—the meter, the gram and the liter. The rest are optional names for decimal steps. Thus the distance from Boston to New York, by the New Haven railroad, is 369 kilometers; but that is only another way of saying 369 thousand meters.

The great advantages of the metric system are its widespread international use, its simplicity and its uniformity all

[1] Given to the air from Station W.E.E.I., Boston, 1926.

over the world. We know that there are two kinds of tons, three kinds of quarts and many bushels; but there is only one meter. This is because there is only one meter standard, which is preserved in an underground vault in the International Bureau of Weights and Measures at Sèvres, near Paris, France. In 1872, France donated a small old royal palace and twenty-five thousand square meters of land to the International Bureau for this purpose. The old palace at Sèvres stands within the old royal park of St. Cloud. Princess Mathilde once lived there. It is not far from the famous Sèvres porcelain factory, and it has been relinquished by France to international jurisdiction. Presumably, it pays no taxes, and a French policeman could make no arrest there. Facing the old palace, or pavilion, a new laboratory building was erected in 1875, with double walls, to keep the internal temperature nearly uniform all the year round. In this laboratory, copies of the international meter bar are made and compared. Each bar is of special platinum alloy, which preserves an untarnished silvery surface. A standard bar has two scratches cut across its face with a diamond, one at each end. The distance along the bar, between these scratches, is set for one meter, when the bar is kept at the temperature of melting ice. Various working copies of the standard meter are kept in the laboratory; but the standard itself is deposited in the vault, eight meters deep below ground. The vault is opened once every six years, in the presence of witnesses, to demonstrate that the standard meter and standard kilogram are in safe preservation. Twenty-eight countries jointly maintain this international bureau. Four special keys are successively needed to open the vault, and three of them are in the custody of foreign delegates to the International Committee; so that the vault can only be opened when the committee meets at six-year intervals. During the great war, one of these keys was in Germany. If it had been necessary to open the vault during the war, it could only have been done by breaking in. Platinum alloy copies of the meter have been distributed among the nations of the civilized world. They are believed to have been correctly compared with the standard at Sèvres, to a precision of at least one part in five millions. There are two of these certified standard meters in the United States, and all our accurate measures of length in industry and in surveying are ultimately connected with these standards. Such standard bars are treated with the greatest care, lest they should be injured by a jolt or fall. Occasionally such national copies of the international meter are returned to Sèvres, for recomparison and check. In all these cases they are taken by a special messenger. It is no wonder, therefore, that the meter has the same length in all parts of the world.

All the civilized countries of the globe have successively either adopted the metric system in their everyday life or they have taken steps officially to do so in the near future, the English-speaking countries only excepted. But although the English-speaking countries have not yet taken any official action towards the general adoption of the system yet an impartial inquiry into the history of the last thirty years will probably show that we are actually already in process of gradual transition to the metric system, though how many years it will take to make the transition complete no one can say without the gift of prophecy. Substantially all the precise American scientific work is now carried on in the metric system. A few departments of the U. S. government use the system every day; namely, the Coast and Geodetic Survey, a part of the U. S. Customs, and the medical departments of the Army and Navy. There is at least one Amer-

ican industry that uses the system exclusively; *i.e.*, the business of making lenses for eye-glasses and spectacles. All such lenses are prescribed and constructed in the metric system. Many thousands of monthly bills to consumers of electricity for electric light and power are made out in terms of the kilowatt-hour, a unit based on the metric system. All our radio wave-lengths are measured and specified in meters. A few American manufacturing firms have voluntarily changed over to the metric system in their factories, for the sake of convenience and simplicity. Their testimony has been that while there was a certain inconvenience and bother in making over lists, schedules, drawings and stock-sheets for a little while after the change, the cost was trivial, and no machinery had to be discarded. Our coinage is associated with the system; because a new nickel, or five-cent piece, weighs just five grams, and our silver coins, from the half-dollar down, weigh at the rate of twenty-five grams to the dollar.

Out of the twenty-five large countries and more than fifty little ones that have already given up their original systems and adopted the metric system, none has ever revoked its decision.

A large element of the steadily increasing trend towards the metric system in our country doubtless comes from the fact that modern communication has greatly increased the interchange of methods and ideas between the nations through the telegraph, the telephone and radio.

The invisible radio waves spread from a transmitting station, in all directions, with the enormous speed of light. The radio waves now carrying my voice far and wide are believed to spread over the globe and to reach the furthest opposite point, or antipodes, near Perth in Western Australia, in about one tenth of a second of time. The waves from WEEI in Boston have not yet been picked up in Australia, so far as I know; but I am informed, through the courtesy of the officers of WEEI, that the friendly voice has been caught and identified by radio receivers in various remote places as far west as the Pacific coast and as far east in Europe as England, Belgium and Sweden. In the case of more powerful radio-telegraph stations, signals have often been received at or near their antipodes, just twenty thousand kilometers away, over the seas. This means that in relation to communication of ideas by radio, the most remote countries are only about one tenth of a second apart. We all live on a tenth-of-a-second radio world. It does not seem likely that such a world can indefinitely support more than one system of weights and measures. It must only be a question of time, on a tenth second world, when only one system will supervene. Will this surviving system be the sixty-unit English system, the fifty-unit American system, or the three-unit metric system?

THE ANCIENT AND MODERN USE OF PLANT ARROW POISONS

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I. Ancient Record

How certain plants came to be used to poison the tips of arrows is not a question of general agreement. There are two main theories. The snake-bite theory assumes that the natives, upon witnessing the terrible effects of a snake bite, which was apparently accomplished by merely piercing the skin with a sharp point and injecting poison, came to smear the sharp arrow tip when hunting or in warfare. The latex-smear theory suggests that natives, upon being wounded, would naturally smear the juice or gummy exudate of some plant to arrest the blood flow and to heal. Some noted that the use of certain plants resulted in immediate poisoning and death. It is not too much to assume that sooner or later some native applied it to his arrow tip in order to carry the poison into the body of his game or to destroy his enemy in combat. Whatever the origin, the beginning of the use of arrow poisons is lost in antiquity.

A monographic treatment of plant arrow poisons would necessitate investigations in the fields of physiology, medicine, ethnology and even the study of the handicraft and decorative art of the indigenous tribes. Many startling and imaginative tales have been recorded in the literature. It is the purpose of this paper[2] to discuss the actual past and present employment of vegetable arrow poisons.

[2] Other papers now in preparation deal with the geographical distribution of the plant sources of arrow poisons and with the comparison of the physiological effect of the native arrow poisons with the pure drug.

The general application of poisoned arrows by ancient people is referred to in many instances by the early writers. The Biblical record in the Book of Job (VI–4) shows that the people of that period knew of arrow poisons. Homer indicates that the early Greeks were familiar with the practice. He has written in Odyssey I, page 260:

> He [Odysseus] came seeking the deadly drug, wherewith to anoint his bronze tipped arrows. He [*i.e.*, some unknown friend he had sought it from] did not give it to Odysseus—but my father gave him the drug, for he loved him exceedingly.

The nature of this poison is unknown but probably was of vegetable origin, as the word "unguere" (anoint) indicates. In fact, even the derivation of our term "toxic" is intimately associated with arrows and poison. To wit:

- Τόξον, a bow.
- Τόξα (the plural), often used for bow and arrows; the singular also sometimes has this use.
- Τα Τόξα, for arrows only in Sophocles and in Plato Laws.
- Τὸ Τοξικον (supply Φαρμακον), poison for smearing arrows, in the writings of Dioscorides, a physician of about 60 A. D.

Toxic means poisonous. A toxophilite is a lover of archery.

Virgil has written in Aeneid IX–772:

> There was no other man more skilled of hand than he
> In tincturing darts and arming steel with poison.

Horace infers in his ode to Aristius Fuscus[3] that African tribes along the

[3] Q. Horatii-Flacci, Opera, Lib. I, carm. XIX, Ode XXII.

northwest coast used arrow poisons. He has written:

> Integer vitae scelerisque purus
> Non eget Mauris jaculis, neque arcu,
> Nec venenatis gravida sagitta
> Fusce, pharetra.

Theophrastus[4] and Claudius[5] spoke of the Ethiopian arrow poisons. Although many of the natives in the regions of Africa which have been invaded by Europeans have given up arrows and arrow poisons in favor of firearms, there are, nevertheless, millions of people who still depend upon primitive weapons.

In Asia, as in Africa, reference to arrow poisons has been made by the earliest explorers. The most toxic arrow preparation of vegetable source in the Malay Archipelago is *Upas* or *Ipoh*. Rhumpius explains that both *Upas* and *Ipo* are to be translated as poison. *Pohon* is a tree. Hence, *Pohon-Upas* refers to a poisonous tree. *Radja* always signifies a chief or ruler or one who rejoices in power. The term, therefore, of *Upas-Radja* in early literature indicates that this plant arrow poison is a very powerful one.

Early literature dealing with South America is rich in records of vegetable arrow poisons, especially *Uirarery* or *Ourari*, which, in its modern spelling, is *Curare*. The first Spaniards who began the conquest of South America found plant arrow poisons in effective use. The early sixteenth century travelers, who explored the Magdalena River in northwestern South America, had great trouble in persuading their fellows to venture into the wilderness. The first sample of *Curare* was carried into Europe from British Guiana, in 1595, by Sir Walter Raleigh and was called *Ourari*.

Very few plant arrow poisons have been employed commonly in North America, although arrows and blowguns were the weapons. *Anemone* species of the Crowfoot family were used in northwestern Alaska. The stems of three or four plants were collected for the preparation of poisons in southwestern Oregon. The Erie Indians are reported[6] to have applied poisons to their arrows about 1635, but it is not known what plants, if any, were employed. Only a few tribes of Mexican Indians, especially the Seri in Sonora, indulged in this practice. They prepared the toxic paste principally from the latex of *Sebastiana Palmeri* Riley.

II. Modern Record

The modern use of plant arrow poisons is limited to the same geographical areas as in the past; namely, the greater part of Africa, northern India, southern and southeastern Asia, the Malay Archipelago, the Philippine Islands, the northern half of South America and by a few tribes in Japan, Alaska, Mexico and Central America. In many instances, natives have abandoned arrows for modern weapons but soak their bullets in their traditional arrow poison.

To-day, the principal plants used in Africa are various *Strychnos* species, *Strophanthus Kombe* Oliver, *S. hispidus* DC., *Calotropis procera* (Ait.) R.Br., *Acocanthera venenata* Don, *Adenium Boehmianum* Schinz., *Physostigma venenosum* Balfour, *Haemanthus toxicarius* L. (*Buphane toxicaria* (L.f.) Herb.), and *Erythrophloem guineense* Don. In 1905, Chambers[7] described the Fra Fra arrow poison in the Gold Coast Colony of Africa. This poison was responsible for the death, in about twenty minutes, of fifteen out of forty-five soldiers in the French Sudan. Leprince[8] investigated

[4] Theophrastii, Eresii, Opera, Part 1, Bk. IX, chap. XV.

[5] Claudianus, Cl., "De consulatu Stilichonis," Bk. 1, p. 351.

[6] Le Mercier, "The Jesuit Relat.," ed. Thwaites.

[7] Chambers, A., "*Journ. Roy. Army Med. Corps*, 5 (1905), 213–223.

[8] Leprince, M., "Étude pharmacognosique de l'*Adenium*" (1911).

the effect of arrow poison prepared from *Adenium*. Frolich[9] studied the effect of Muchi arrow poison. Lewin[10] discussed the preparation and effect of numerous African arrow poisons of vegetable origin.

In the Malay Archipelago, the chief arrow poison is *Ipoh,* which is prepared from a large tree, *Antiaris toxicaria* Leschen. The latex is evaporated down and smeared on the arrows. The effect[11] of this poison is fatal to man. Lewin[12] described the effect of Dyak poison on various animals. Plant arrow poisons, known as *Ipoh,* are prepared from several sources in some localities throughout the Malay peninsula. The plant customarily substituted for *Antiaris* is *Strychnos tieute* Leschen. The Negritos in the mountainous regions of the Philippine Islands still (1926) use arrow poisons prepared from *Lunasia amara* Blanco and *Lophopetalum toxicum* Loher.

Curare, the chief South American arrow poison, is obtained in most cases from the bindweed, *Strychnos toxifera* Schomb., *S. Gubleri* Planch. or *S. Castelnaei* Wedd. This poison is imported into the United States via Germany for use in our medical schools and physiological laboratories. Whereas, the African and Asiatic *Strychnos* arrow poison acts upon the spinal cord, curare centers its action upon the motor end-plates. Curare and other arrow poisons are used by some practically unknown tribes of Indians who inhabit but slightly explored areas. Further investigation of these regions will probably disclose interesting information both in regard to the racial differences in these people, already noted in captured individuals, and in the plant sources of their deadly preparations.

9 Frolich, A., *Journ. Physiol.*, 32 (1905), 319.

10 Lewin, L., "Die Pfeilgifte," (1923).

11 Roth, H. L., "The Natives of Sarawak and British North Borneo," 2, (1896).

12 Lewin, L., "Die Pfeilgifte," (1923).

Dr. W. L. Schurz[13] has called attention to a South American tree called "*assacú,*" which is feared by the natives because of the powerful astringent poison in its sap. The toxic flora of the Amazon includes poisons whose virtues are known only to the Indians. These toxins include the terrible *mata calado* or silent death, which is reputed to leave no trace in the system, as is apparently true of the Central American *camotillo;* and the capanço, about whose powers many tales are told.

The preparation of arrow poisons has always been carefully guarded as a secret to be religiously kept from the knowledge of others. The efficacy of these native plant poisons has been a source of terror to explorers. The most recent account[14] of the mystery and effect of Indian poisons is in connection with the death of Ogden T. McClurg, the publisher, who is believed to have been the victim of a Central American Maya poison. He died under peculiar circumstances and physicians were unable to assign any reason for his sudden death. Mr. McClurg was a member of the Mason-Spinden expedition to Yucatan. Twice he was ambushed by Maya Indians. The possibility of his having been merely scratched by a poisoned dart is now being discussed. This Maya poison is reported by R. J. Urruela, of San Salvador, to produce lethal results but without leaving detectable traces in the system. Senor Urruela calls this poison "*camotillo*" and says that it has been known to the Mayas for centuries. I will quote from his report regarding this poison as follows:

> I knew camotillo by legend. Now I know it by the terrible experience of fact. Three deaths of prominent political men in Latin America have given me the absolute certainty of its menacing existence and its lethal effects.

13 Schurz, W. L., *National Geog. Mag.*, XLIX, No. 4 (April, 1926), 455.

14 White, A. R., N. Y. *Evening World,* April 27, 1926.

. . . I determined to get definite information about camotillo. I left for Copan, Honduras, where the ruins of the Maya temples are located. . . . Finally I met a Spanish priest who had charge of one of the many churches in Copan. . . . He told me that the Maya tribes are the only ones that possess the secret and they live far in the interior, in Atlantida, where there are no roads and but one white man is allowed to enter their domains. He is the priest in charge of their church. If you can meet him, he will give you all the information that is to be had about camotillo. . . . I met Padre Nicolas, a Spaniard.

Padre Nicolas spoke as follows: "I came to this tribe, called the Chancatales, which means 'the never defeated,' by order of my superior, the Bishop of Copan. I am the only white man allowed in their city, which is many miles inland. Sentinels are scattered all over the woods. Every stranger who approaches is immediately signaled. If he refuses to turn back he will never be seen by his people again. The Chancatales clan is ruled by a group of brujos (wizards) who have inherited the secrets of their forefathers. The brujos are the only ones who understand the preparation of camotillo. The poison is obtained from a vegetable bulb, in appearance very similar to a potato. It grows wild and cannot be found except by one who knows. The bulb is dried and passes through a series of manipulations until finally it is ground to powder. In the same length of time taken to dry and grind the bulb, the preparation will work its effect. A camotillo dried and ground in eleven moons will take eleven moons to kill. They can predict the occurrence of death with uncanny accuracy."

How much of this case of Maya poison is fact and fiction is difficult to ascertain. It is evident, however, that the prevalent use of plant poisons on arrows, darts and in other ways with criminal intent demands the attention of the tropical physician, traveler and explorer. It is significant that the natives have selected by some means, probably by the disastrous trial and error process, the most toxic plants in their respective localities as the sources of their poisons. The arrow poison plants are, therefore, indicative of the local toxic flora. There is much to be accomplished by research on the plant sources, uses and antidotes for vegetable arrow poisons.

WHAT IS AN INSTITUTION?

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THE interesting article of Professor Ezra Bowen in the April SCIENTIFIC MONTHLY calls for a supplement.

He truly says that private possession exists in its most absolute form in primitive society, but he confuses the mere fact of physical possession with an *institution* of private property. He gives no hint as to what an institution really is. And the facts he adduces have little or no bearing on the question he is arguing: what were the earliest forms of the institution of property? Mere physical possession he calls the "oldest and most uncompromising of social institutions." In reality, however, mere possession by the strong individual does not imply the existence of an institution of private property.

If (as he says) in time of drought the one remaining water-hole is monopolized by one enormous hippopotamus, that does not indicate that there is an institution of private property, neither does the dog's monopoly of his bone, the child's monopoly of his drum or the savage's monopoly of a well-shaped club that he has found or made or taken from a fallen foe. The institution of private property does not begin till society decides to protect the possessor in his possession and decides also on what terms and within what limits society will so protect him. The institution of private property defines and limits as well as protects the right of possession. Mere possession of the primitive sort is based on might and has nothing to do with right nor with any institution.

A relatively primitive institution regarding private property is to be seen in the rules by which an Australian hunter divides the kangaroo which he has slain among his relatives—rules which require him to make this division as well as protect him in his own share.

True, as Professor Bowen says, we no longer bury a dead man's property with him for we no longer fear his ghost. We have substituted the institution of inheritance, a purely social convention grounded on a judgment of social expediency and limited, if society so wills, and to any degree which society finds expedient, by the taxation of inheritances, by primogeniture or even by escheat. Taxes, eminent domain and police power are social institutions, but mere crude and primitive possession by the strong is not a social institution.

There have been scholars who insisted that only might makes right and that anything is right which can be enforced. They were utterly wrong when they meant that the assertion of interest or impulse by an individual against other individuals or by a class or group against other classes or groups created a right by virtue of the fact that the claim was asserted and enforced. But they would not have been wrong if they had said and meant that what the judgment and sentiment of a society enforces upon its own members is in that society right. "Right" as well as "rights" are social concepts, and as Professor Sumner says, "society can make anything right" in that society.

These two statements include the reasons why problems of ethics are matter-of-fact problems and why the study of ethics is no more the affair of meta-

physical speculation than the problems of agriculture or of bridge building. The history of moral codes is altogether a part of the story of social evolution, and the criticism of moral codes is altogether a matter of fact inquiry. We still give to one who is trained in chemistry or physics the degree of doctor of philosophy. This is reminiscent of the period in which all sciences were only emerging from the metaphysical stage, as now at length ethics has begun to emerge. That ethics has thus begun to emerge from the metaphysical stage and to be treated as a matter of social evolution and practical social inquiry is perhaps the most important part of what sociology is bringing to pass.

The institutional definition of property rights is based on the perceptions (1) that private possession rewards and elicits productive effort, (2) secures orderly and efficient administration of material resources and (3) is just. By "just" we mean that it is an arrangement consonant with a balanced regard for all the interests affected. The institution of private property as distinguished from the mere fact of possession is an effort on the part of society so to define, limit and protect possession as to secure so far as practicable the three results just specified: reward and promotion of productive effort, orderly and efficient administration of material resources and justice. Any limitation of the rights of private possession or redefinition of them which is required by these three criteria is not only justified, but demanded.

An institution is a mode of social activity. It is one of those socially evolved and socially prevalent activities which are included in the "culture" of a people. Whether one is a behaviorist or not, from any scientific point of view having an idea or having a feeling is an activity as truly as driving a nail. Ideas and feelings are elements in all distinctively human activity, whether the activity completes itself in overt muscular movement or not. Any social activity that can be called an institution is essentially a set of ideas and feelings that prevail in a society and that go over into overt conduct when occasion arises, together with a prevalent habitual disposition to these activities. Fundamentally institutions are states of mind, *i.e.*, ideas and feelings are their essence. An institution like trial by jury, when the activity becomes overt, supplies itself with a personnel, such as judges, lawyers, jurors and bailiffs, and with a material equipment, such as court house, bench, bar and jury-box, but the building may be burned, the personnel beheaded and the surviving members of the society may migrate to a new continent, yet they will carry their institutions with them if they retain their habitual states of mind.

An institution is a mode of social behavior and one which in contrast with mere fashion and custom includes an element of rationality, a practical judgment, approving both the ends sought and the methods employed in the activity.

Human culture has three stages. In the first it is molded by biological necessity. Group practices are defined by the requirements of group survival. In the second stage, death being somewhat held at bay, there is room for many nonadvantageous vagaries. In the third stage, rational acceptance in the light of experience converts useful customs into institutions and invents new institutional forms. And ripened institutions, economic, domestic, political, etc., have striking resemblances to the group customs which at an earlier stage were enforced by biological necessity.

TWO ENTOMOLOGISTS OF THE EIGHTEENTH CENTURY—ELEAZAR ALBIN AND MOSES HARRIS

By HARRY B. WEISS

NEW BRUNSWICK, N. J.

Eleazar Albin

"Now it is the general complaint of the taverns, the coffee-houses, the shopkeepers and others that their customers are afraid when it is dark to come to their houses and shops for fear that their hats and wigs should be snitched from their heads or their swords taken from their sides, or that they may be blinded, knocked down, cut or stabbed; nay the coaches cannot secure them, but they are likewise cut and robbed in the public streets, &c. By which means the traffic of the City is much interrupted." So said the city marshal of London in 1718. On the other hand, there was the small but lively world of fashion, politics, literature and art with its phosphorescent society of statesmen, politicians, authors, wits, rakes and dandies.

This is the London that Eleazar Albin knew, a London in which the forces of disorder were strong and a London whose *beau monde* enabled him to make a living. Of German origin, his family name having been Weiss, Albin taught drawing and painting in water-colors. This led to an interest in flowers and insects, especially the latter, which he painted at first simply for his own pleasure. Later he became acquainted with a collector, a Mr. Dandridge, who employed him in painting caterpillars and who also recommended him to Mrs. Howe, widow of Dr. George Howe, of the College of Physicians of London, who died in 1710. Mrs. Howe's interest being in the Lepidoptera, Albin painted a large number of butterflies and caterpillars for her. He also did several things relating to natural history for Sir Hans Sloane, erroneously considered by many as having been the sole founder of the British Museum, when, as a matter of fact, there had been, long before Sloane's time, sedulous and frequent efforts to arouse the government to the importance of public museums. Sloane's will, however, did provide the opportunity for the foundation.

Following his work for Sloane, Albin was introduced to Her Grace Mary, Duchess Dowager of Beaufort, who employed him in a similar manner and advised him to embark on his "Natural History of English Insects," giving him such substantial aid as securing subscriptions from several persons of the "first quality." While she lived, Albin made rapid progress on his book, but after her death the subscriptions dropped off and the work was delayed. Albin had a "great" family and needed the subscriptions in order to complete the book. About 170 subscribers were finally secured and the work appeared in 1720, entitled "A Natural History of English Insects, illustrated with a Hundred Copper Plates, Curiously Engraved from the Life; And (for those who desire it) Exactly Coloured by the Author."

Among the subscribers were members of the nobility, an apothecary, a stationer, a music teacher, a chemist, a surgeon, the treasurer of the East-India Company, a gardener, a lawyer, a doctor, a merchant, a professor and a gentleman. Some of the subscribers were

Lord Bruce, the Earl of Cardigan, the Duke of Devonshire, who was the Lord Steward of the King's Court, the Earl of Strafford, the Countess of Salisbury, Mrs. Howard the Countess of Suffolk, society and Court favorite, Lady Stuart, etc.

The book for the most part deals with the Lepidoptera, although a few insects of other orders are included. Each plate is dedicated to a subscriber and accompanied by a page of text. The plates illustrate the adult insects, larvae, pupae and food plants, while the text describes the colors of the species, eggs, early stages, food plants, parasites, remedies for the injurious insects and miscellaneous observations, all rather briefly. In the introduction Albin says that during all his observations he did not meet with one instance that gave him reason to doubt that insects in general were produced by parents of the same species and remarks with some naïveté that in this he is confirmed by Redi's book, "Experiments on the Generation of Insects," which, incidentally, appeared in 1668. A second edition of Albin's book "with Notes and Observations" by W. Derham appeared in London, 1724, a third edition in Latin in 1731 and a fourth in 1749.

His next book venture was "A Natural History of Birds," in three volumes, 1731, 1734 and 1738, accompanied by a total of 306 copper plates colored by himself and his daughter Elizabeth, whom he had taught to draw and paint. A second edition was printed in 1738–1740, and a translation, supplemented with notes and remarks by W. Derham, was published in French at Hague in 1750.

William Derham was a minister who was interested in natural history and mechanics. He wrote a number of papers on various subjects, including the migration of birds, the weather, the habits of the deathwatch and of wasps, etc., and had a large collection of birds and insects. He also published religious works of his own and edited the correspondence of John Ray.

Albin solicits, in his "Natural History of Birds," presents of curious birds and advises the prospective donors that the specimens should be sent to him in the comfortable vicinage of the "Dog and Duck." To Sir Robert Abdy, who helped him in the collection of birds and on various occasions, the first two volumes are dedicated; the third volume to Richard Mead, physician in ordinary to George II, a man who had a high reputation as a practitioner and writer on medical subjects and who devoted much study to natural history and antiquarianism.

Each plate of Albin's bird book is accompanied by a page of text, but the plates are not dedicated to subscribers, at least not in the second edition. His plates are said to be greatly inferior to those in Catesby's "Natural History of Carolina," and one critic stated that Albin must have been ignorant of ornithology.

Albin's next book was "A Natural History of Spiders and other Curious Insects, Illustrated with Fifty-three Copper Plates Engraved by the Best Hands," which was published in London in 1736. In his statement "To the Reader," Albin quotes from the "Spectator" No. 121, published some twenty-five years before, in which Addison expresses the wish that some one would "take each his particular species and give a distinct account of the frame and texture of its parts—especially those that would distinguish it from other animals," believing that such studies would be a service to mankind. Albin somewhat pompously says that on the wish of Addison he built his book on spiders, describing two hundred different kinds and giving the results of his own observations. The work is dedicated to

Dr. Mead and contains the names of some sixty-four subscribers, including those of eight booksellers. Among the subscribers are the Empress of Russia, the Countess of Suffolk, who numbered among her friends many of the men of letters of her time, Pope, Gay, Swift, Arbuthnot, etc., and who was the mistress of the Prince of Wales, afterwards George II, Sir Hans Sloane, who subscribed to all Albin's works, Lady Mary Booth, Lady Mary Gore and many other members of the court circle around the periphery of which Albin hovered.

To Albin's treatise on spiders are appended three short papers, one entitled "Of the Tarantula" by Dr. Mead, and the remaining two, "Microscopical Observations on the Carter Spider, and Jumping Spider," and "Observations on the Flea, and Louse," both by "the late ingenious Dr. Hooke, F.R.S." Some of the plates are signed by Albin as artist, and Thomas Martyn, who made Albin's work the basis of a more comprehensive volume in 1793, praised the drawings for their correctness but disapproved of the text as being disconnected and without order, although at times entertaining and instructive. The frontispiece consists of a portrait of Albin on horseback, said to be by J. Scotin, surrounded by pictures of spiders, mites and scorpions, although the plate, dated 1737, is signed by Albin as artist and by Scotin as engraver. Jean Baptiste Scotin flourished in Paris during the first half of the eighteenth century and engraved after H. Rigaud, Boucher, Watteau, Lancret, Pater and other French painters. In the illustration Albin, on his white horse and resplendent in a green coat and black hat, outshines the surrounding arthropods.

In 1737 his "Natural History of English Songbirds," with colored plates, appeared, later editions being printed in 1747, 1759, 1779, London, and an Edinburgh edition in 1776. His last work, entitled "The History of Esculent Fish," with plates drawn and engraved by E. Albin and with an essay on the breeding of fish and construction of fish ponds by Roger North, a lawyer and historian who died in 1734, was not published until 1794. It is illustrated by some eighteen plates signed variously by E. Albin, Elizabeth Albin, Eleazar Albin, Eliza Albin, Eliz. Albin and Fortin Albin, and dated 1735, 1736, 1739, 1740, etc. Fuseli, the designer and painter, who was also interested in entomology, found in a catalogue under Albin the three names Eleazar, Elizabeth and Fortin, and speculated upon the relationship of the first and last two. Elizabeth was Eleazar's daughter, as noted heretofore, and although nothing is said in the text of Albin's books, the fact that three of the fish plates are signed by Fortin and accompanied by plates by both Elizabeth and Eleazar seems to indicate a relationship, possibly that of father and son.

Nothing is known of the dates of Albin's birth and death. He flourished from about 1713 to 1759, and according to Bryan's "Dictionary of Painters and Engravers," there is a "Rich Man and Lazarus," by him in the Gallery at Cassel. His portrait indicates that he was a rather well-built man, probably somewhat swanky in view of the "quality" of his patrons and subscribers, and withal perhaps rather lacking in a sense of humor so far as he himself was concerned, as evinced by his equestrian representation, his green coat and his black hat. Nevertheless, Albin put something of himself in each of his books and there is a certain friendliness about them which is non-existent in the cold, impersonal and standardized manuals of to-day.

Moses Harris

The great fire of London broke out on September 2, 1666, and Evelyn, as recorded in his "Diary" on September 3, "saw the whole south part of the city

TITLE PAGE OF ALBIN'S "NATURAL HISTORY OF ENGLISH INSECTS," 1720, AND PLATE 53 DEDICATED TO SIR HANS SLOANE.

burning, from Cheapside to the Thames, and all along Cornhill (for it likewise kindled back against the wind as well as forward), Tower Street, Fenchurch Street, Gracechurch Street, and so along to Bayard's Castle." Under the entry dated September 7, at which time the fire was almost out, he speaks of the ruin and desolation and of going on foot through the various streets or what was left of them and "thence through Cornhill, with extraordinary difficulty clambering over heaps of yet smoking rubbish, and frequently mistaking" his location.

In this fire, in the Cornhill section, perished the collection and books of the Society of Aurelians to which Moses Harris's uncle of the same name later belonged. The society held its meetings in the Swan Tavern in Change Alley, and the members who were sitting at the time "had to escape suddenly, many leaving their hats and canes." However, it does not seem likely that even entomologists would delay their departure until the fire was so close upon them. The Swan Tavern may have been the one said to have been rebuilt as the Swan and Rummer after the fire and often frequented in the early part of the eighteenth century by Gay, Swift, Arbuthnot and other brilliant wits of that age and from which they would be chaired home after a sparkling evening.

Moses received his first instructions in collecting insects at about the age of twelve, from his uncle, who must have been close to ninety at the time, if rather uncertain dates are accepted. For more than twenty years he collected insects and drew, engraved and colored them, chiefly moths and butterflies, being an acute observer and a good entomolog-

UPPER: FRONTISPIECE AND TITLE PAGE OF THE "AURELIAN," 1778, BY MOSES HARRIS. LOWER: FRONTISPIECE AND TITLE PAGE OF ALBIN'S "NATURAL HISTORY OF SPIDERS AND OTHER CURIOS INSECTS," 1736.

ical artist and engraver on copper. This industry bore fruit in the shape of his book entitled "The Aurelian or Natural History of English Insects; namely, Moths and Butterflies, together with the Plants on which they Feed," which he published in London in 1766. The title page also bears the statement that the work is "A faithful Account of their respective Changes; their usual Haunts when in the winged State; and their standard Names, as given and established by the worthy and ingenious Society of Aurelians" of which Harris was secretary.

The forty-five plates, for the most part dedicated to members of the aristocracy, were drawn, engraved and colored by the author. Harris states in the introduction that he had many pleasant collecting trips during the pursuit of his work. A large part of the prelude is concerned with the general life-history of the Lepidoptera, collecting nets and how to use them, boxes, setting boards, etc., while the text proper deals with descriptions and markings of adults and notes on life-histories and food plants. The frontispiece consists of a sylvan scene, including a portrait of the author sitting on the bank of a stream, a collecting net over his knees, a chip box of butterflies and other insects in his left hand and his right hand pointing to a small figure, of himself presumably, using the net on the opposite side of the stream. The plate is signed by Harris. The title page of the copy of this work in the American Museum of Natural History library bears the following statement, "Printed for the author, London 1766, and with great additions, for J. Robson, New Bond Street MDCCLXXVIII," and the text is in both English and French, parallel columns. Harris also drew, etched and colored most of the plates in the three volumes of Dru Drury's "Illustrations of Natural History" published 1770–82 and contributed some unimportant drawings to the Catalogue of Andrew Peter Dupont's Collection of Natural Curiosities.

Harris's "Natural History of English Insects" was reissued in 1778, 1794 and in 1840 under the editorship of J. O. Westwood. Hagen was of the opinion that the "Aurelian" originally appeared in numbers. After the first edition was printed, Harris published an appendix which was sold separately, according to the announcement in his "Pocket Companion" of 1775. In 1827 there appeared in the "Retrospective Review" (London) an index of modern generic names for Harris's "Aurelian."

The first attempt to classify Lepidoptera according to the venation of the wings was made by Harris in "An Essay preceding (sic) a Supplement to the Aurelian wherein are considered the Tendons and Membranes of the wings of Butterflies, &c," published by the author in 1767 (London). In this essay attention was paid also to the differences in shape in the scales and of the hooks. In this work the author's name is followed by the words "Miniature-Printer."

Harris's next book was "The English Lepidoptera, or the Aurelian's Pocket Companion, containing a Catalogue of upward of four hundred Moths and Butterflies, &c," printed in London, 1775. This was followed in 1776 by "An Exposition of English Insects," in English and French, which dealt mainly with the Neuroptera, Diptera and Hymenoptera. In the preface Harris states that although it is customary for authors to apologize for those who study natural history, he is at a loss to know "to whom such apology should be made," as those who object "are generally men of small capacity and low wit, having a mean conception of things in general." Copies were issued apparently with new title pages dated

1781, 1782, 1783, 1786. Hagen stated that the text in the copies dated 1776, 1781 and 1782 was the same throughout, but that at least thirteen of the plates had been re-engraved once or even twice. He believed that the work originally appeared in numbers and increasing sales made it necessary to re-engrave some of the plates.

Harris's last publication was the "Natural History of Colours" edited by Thomas Martyn, London, 1811, and dedicated to Sir Joshua Reynolds. In the preface, Martyn speaks of Harris as having been dead nearly thirty years, which would make the year of his demise 1781, or thereabouts, but Graves's "Dictionary of Artists" records that a frame of English insects was exhibited by Harris at the Royal Academy in 1785.

Harris is thought to have been born about 1731 or 1734. Little is known of his life, except that he flourished apparently between 1766 and 1785 and wrote and illustrated the books mentioned. From a letter dated April 5, 1770, that was written by Dru Drury to Harris, it appears that Harris was then living some distance from London, was married and had a son. If he did not actually live in London at some time, his books were published there and he probably made many trips to the city. London in many ways did not improve greatly from Albin's to Harris's time, if the statements of various writers can be relied upon. Walpole wrote in 1750, "You will hear little news from England but of robberies, the numbers of disbanded soldiers and sailors have taken to the road or rather to the street." Shebbeare, writing about the middle of the century, said, "In London amongst the lower classes all is anarchy, drunkenness and thievery, in the country, good order, sobriety, and honesty, unless in manufacturing towns, where the resemblance to London is more conspicuous." Grosley, who visited London in 1765, said that "porters, sailors, chairmen and the day labourers who work in the streets are as insolent a rabble as can be met with in countries without law or police" but that citizens and shopkeepers, journeymen and artisans in skilled trades were obliging.

During the eighteenth century England was at war for about half the time, and the changes from war to peace and peace to war were accompanied by disturbing economic conditions. During war, trade was good, but peace brought dullness, inactivity and suffering, filling the jails and debtors' prisons. In addition, work in many London trades was irregular; the tailors, for example, were said in 1747 to be "as numerous as locusts, out of business three or four months of the year, and generally as poor as rats." It would be interesting to know how entomologists, engravers and artists fared with changing business conditions and the varying fortunes of their patrons. Harris's circumstances were thought to have been fairly comfortable, although in the introduction to the "Aurelian" he mentions losses due to the "unsteady and fallacious Behaviour of a Person too nearly connected in my Concerns."

If his portrait is not too flattering, he was of rather slender build, comely and altogether quite prepossessing. He must have been intensely in love with his work, both as an artist and engraver and as an entomologist, for his books leave one with the impression that in them he endeavored to express himself both artistically and entomologically.

THE PROGRESS OF SCIENCE

By Dr. E. E. Slosson

Director of Science Service, Inc., Washington, D. C.

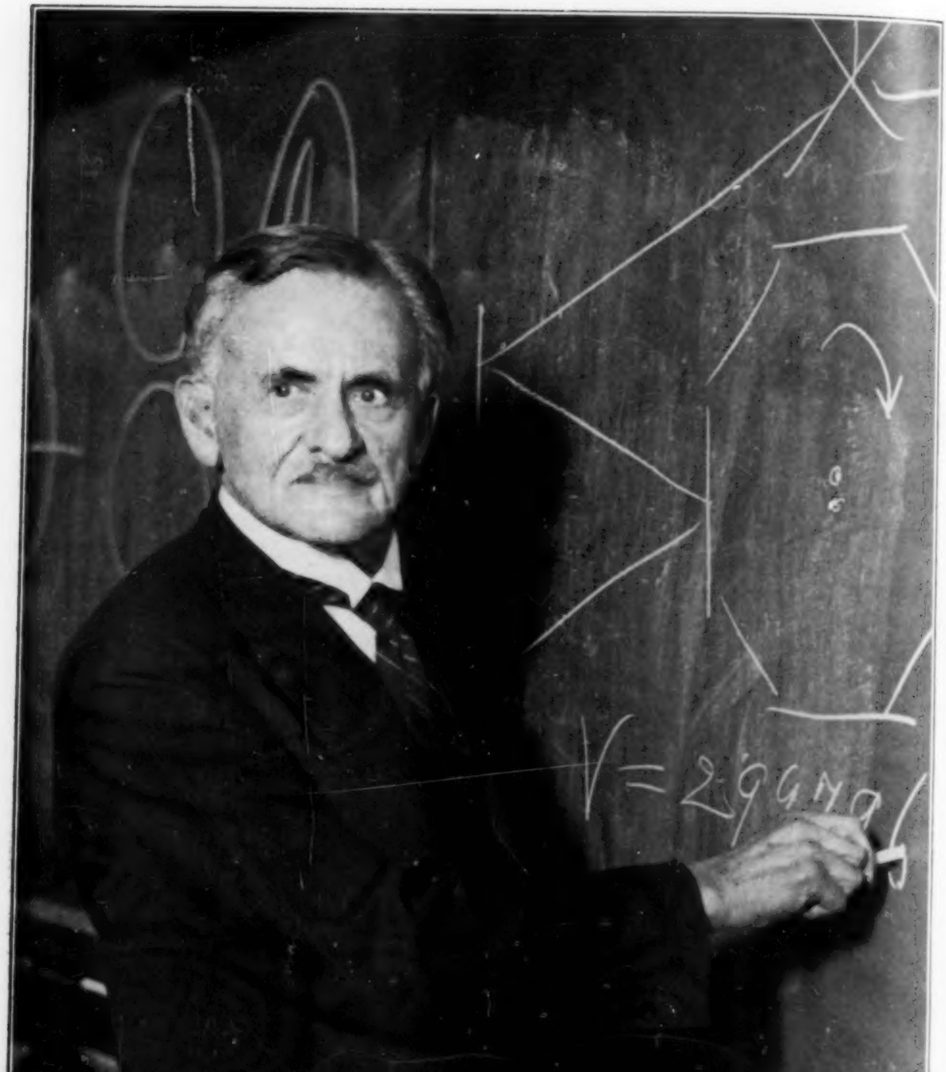
REFRIGERATION BY A FLAME

There are a dozen different household refrigerators now on the market and each is better than all the others. I know that because it has been proved to me in person by representatives of the various manufacturers in the two weeks since I carelessly allowed it to be known that I was thinking of buying an iceless icebox as a surprise to my wife. So many eloquent advocates of family coolers have visited me that I get cold shivers whenever I see a stranger at my door. When the methyl chloride man gets me convinced that he has the best refrigerant, one of the sulfur dioxide agents comes in and overturns all his arguments, and the next caller converts me to iso-butane.

And in the midst of this mental confusion I open the foreign mail and find in *Engineering* and *La Nature* new and original refrigerators have been invented, one cooled by a gas flame and the other by steam.

Both are based upon the familiar principle that the rapid evaporation of a liquid into a gas absorbs heat from its surroundings and accordingly cools them. One uses ammonia for this purpose and the other simply water.

The former is the invention of two Swedes, Baltzat de Platen and Carl G. Menters, of the Royal University of Technology at Stockholm. In employing ammonia as the cooling gas it is like most refrigerating plants, but it has no condensing pump as is customary. In fact it has no machinery, no moving parts of any kind. It consists simply of a series of four tight metal containers, connected by tubes, the whole charged with ammonia, water and hydrogen under a pressure 180 pounds per square inch and hermetically sealed. The first vessel is a generator in which ammonia gas is liberated from the liquor by heating with a gas jet or electric coil. The ammonia gas then passes into a rectifier and condenser where it is cooled by running water and reduced to the liquid state. This liquefied ammonia goes next into the evaporator where it is relieved of its pressure and becomes gaseous again. The evaporator is situated inside the refrigerator-box, which is continually cooled by the expansion of the liquid ammonia into ammonia gas. This finally flows into the absorber where it dissolves in water and runs back to the generator to start upon its rounds once more. The evaporation of the ammonia is due to its fall in pressure from 180 pounds per square inch in the generator to a partial pressure of 30 pounds per square inch in the evaporator. This is accomplished by an ingenious application of a law discovered by John Dalton over a century ago, that the total pressure of a mixture of gases is equal to the sum of the pressures that each gas in the same space would exert if the other gas



DR. ALBERT A. MICHELSON

PROFESSOR OF PHYSICS IN THE UNIVERSITY OF CHICAGO, PRESENTING AT THE PHILADELPHIA MEETING OF THE NATIONAL ACADEMY OF SCIENCES HIS MEASUREMENTS DETERMINING THE VELOCITY OF LIGHT. DR. MICHELSON IS PRESIDENT OF THE ACADEMY.

were absent. Now the evaporator is filled with an atmosphere of hydrogen gas which gives a partial pressure of 150 pounds. When the ammonia which has been liquefied under a pressure of 180 pounds comes into the chamber where the pressure due to hydrogen is only 150 pounds, it evaporates at a rate sufficient to make up the difference between the two, 30 pounds, and this causes the cooling. The hydrogen is kept from getting into the other part of the apparatus by a curved tube filled with water through which ammonia can pass but not hydrogen.

The manufacturers claim that the family-size refrigerator will absorb heat to the amount of 320 British Thermal Units per hour and may be run for a day by currents of 3 kilowatt hours of electricity and about 120 gallons of water. If electricity is not available a gas flame may be used for heating the generator. The apparatus is not at present automatically started and stopped but is so arranged that a single handle turns on the gas and water supply together. So the cook can bake her cake by a gas fire and then switch it over to freeze her ice-cream.

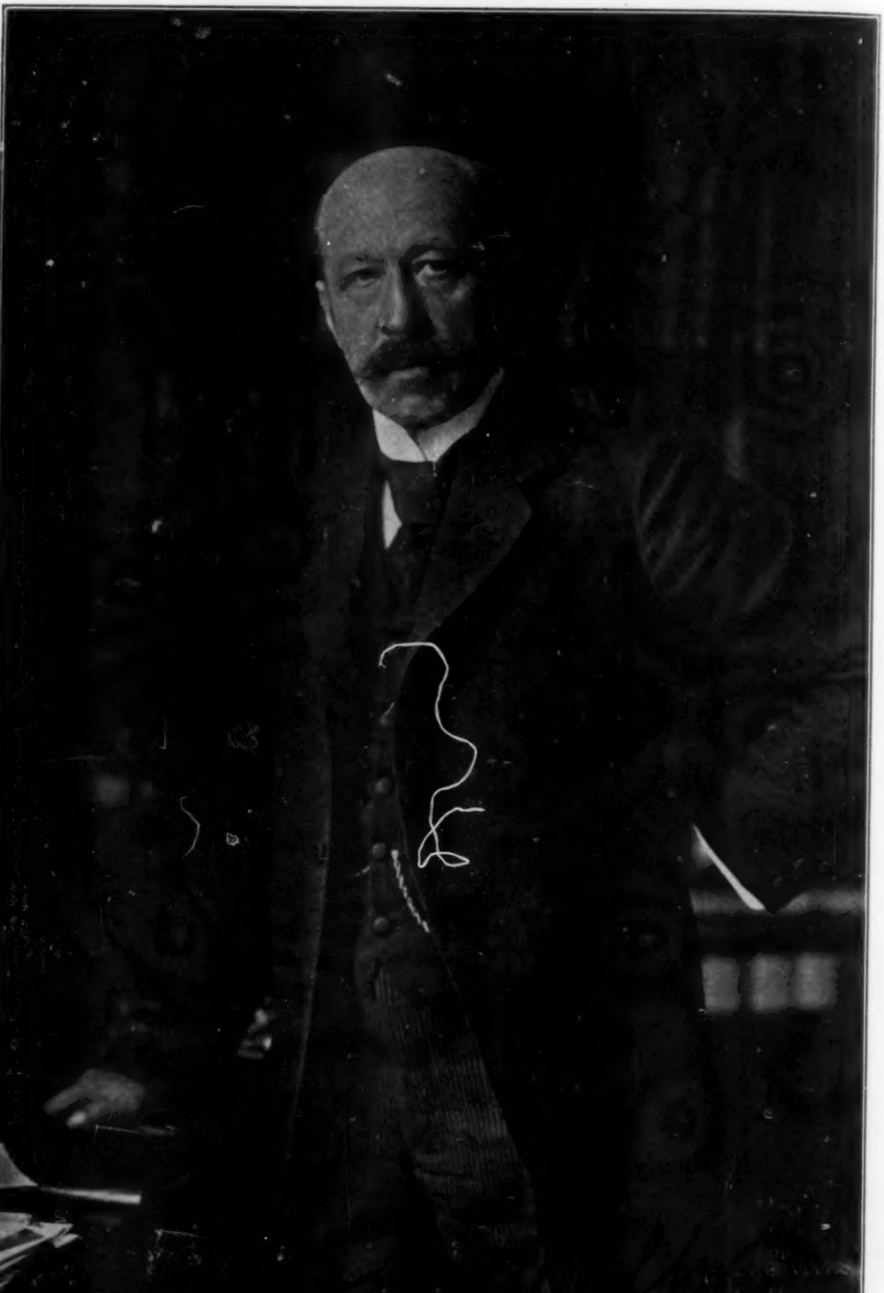
The French machine invented by R. Follain is interesting because water is the only means employed. This is doubly advantageous since water is everywhere cheap and absorbs a larger quantity of heat on evaporation than any other substance known. In this apparatus the evaporation is hastened and therefore the cooling effect is intensified by creating a vacuum above the surface of the water in an airtight tank by the injection of a steam jet in a constricted tube. The water vapor and steam are condensed in an adjoining chamber by a spray of cold water. Several such systems can be arranged in series in order to secure the desired reduction of temperature. Such a machine will cool 1,250 gallons of water from 77 degrees to 37 degrees Fahrenheit. To accomplish this requires about 790 pounds of water used as steam for the injector and 22 tons of water for cooling.

But there is not room enough in our pantry for all this. I think I will postpone my purchase until one of the machines drives all its rivals out of the market. But the danger of such a policy of watchful waiting is that the law of the survival of the fittest does not always hold in the commercial struggle for existence. The machine which comes out supreme in sales may be the poorest and cheapest to make, because it has the largest surplus to spend on advertisements and agents.

THE CATALYSIS OF COAL

In the old days before the war men did not know anything better to do with coal than to burn it. Now they are beginning to find out that it may be put to better purposes as raw material for making more valuable commodities.

In those days too when men wanted to get more gasoline than petroleum contained, they knew no other way to get it than to smash up the big molecules into little ones, to break down the heavy oils to make light oils. This "cracking" process was regarded as a great achievement in its day and brought fame and fortune to its inventor; quite rightly, since we could be running few automobiles without it. But the world is passing into another era now, the age of synthesis, when the chemist will build up instead of breaking down. Starting with the commonest and cheapest materials, air, water and coal, the chemist



DR. FRIEDRICH VON MÜLLER

THE DISTINGUISHED PHYSIOLOGIST AND PATHOLOGIST OF THE UNIVERSITY OF MUNICH, WHO HAS BEEN LECTURING IN THE UNITED STATES.

can construct at will all sorts of valuable compounds for which we formerly had to rely upon nature.

The veteran French chemist Professor Paul Sabatier, of Toulouse, recently on a visit to America, opened the door to this new era with the key called "catalysis." Shortly before the century closed he found that hydrogen gas could be made to unite with carbon monoxide gas in the presence of finely divided nickel and produce methane, well known as natural gas. Now these two constituents, hydrogen and carbon monoxide, are easily made by passing steam over red hot coal, the "water gas" process. Many other metals and compounds have since been found to act like nickel as a catalyst, that is, they speed up a process by their presence without being used up or appearing among the products.

This principle has of late been applied with remarkable results by a countryman of Sabatier, General Georges Patart, and still more extensively in Germany by Professor Franz Fischer, director of the Institute of Coal Research at Muelheim-Ruhr, and Dr. Friedrich Bergius, of Heidelberg. All these three European leaders in catalytic research went to Pittsburgh to attend the International Conference on Coal held at the Carnegie Institute of Technology from November 15 to 19, and what they told of the application of catalysis to industry was new to many of our people, for in this field America is far behind Germany and France.

For instance, we have been making methanol by the old-fashioned method of distilling wood, but now the Badische Chemical Company makes ten to twenty tons of it a day from water gas at a cost of only 20 cents a gallon. Methanol, formerly known as "wood alcohol," has long been employed in all countries as a denaturant for industrial alcohol, and has caused many cases of blindness in Germany and America by being used for whiskey by those who were already so blind as not to tell one alcohol from another. Various other alcohols, such as butyl alcohol, made in America by fermenting corn and used for automobile lacquers, are made in Germany from water gas. The waste gases that in some sections of the United States are still allowed to escape from coke ovens unused are at the mines of Bethune, France, cooled and condensed and utilized for making methane, benzene, ethyl alcohol and ammonia.

Owing to the catalytic process for synthetic ammonia invented by Fritz Haber, Germany is now exporting fertilizer instead of importing it as before the war. About 425,000 tons of free nitrogen from the air is now fixed for fertilizers by catalysis every year, and this takes the place of 2,700,000 tons of Chilean nitrate. But Muscle Shoals still stands idle.

Benzene, which can be made from coal in various ways, is the mother substance of the aromatic family of chemical compounds, a family of over a hundred thousand and rapidly growing. Among these are the aniline dyes and drugs that have made the world brighter and safer in our generation. One of these synthetic products, carbolic acid, is familiarly used as an antiseptic and is nearly as useful but much less familiar as one of the two components of bakelite. The other component, formaldehyde, is also an antiseptic and also made artificially.

The chief stimulus to such investigations in Europe is the search for home-made motor fuel. We Americans are not interested in this question now but some day we shall be, and meantime it is interesting to watch the chemists over the water trying to see how many different things they can make out of common coal, like children playing with the Chinese tangram.

DR. WILLIAM D. COOLIDGE.

THE NEW COOLIDGE CATHODE RAY TUBE

A VACUUM tube which produces as many electrons per second as a ton of radium—and there is only a pound of that rare substance in the world—was announced by Dr. W. D. Coolidge, of the research laboratory of the General Electric Company, at a meeting of the Franklin Institute of Philadelphia, on the occasion of the award to him of the Howard N. Potts gold medal of the institute for his outstanding work in the development of X-ray tubes.

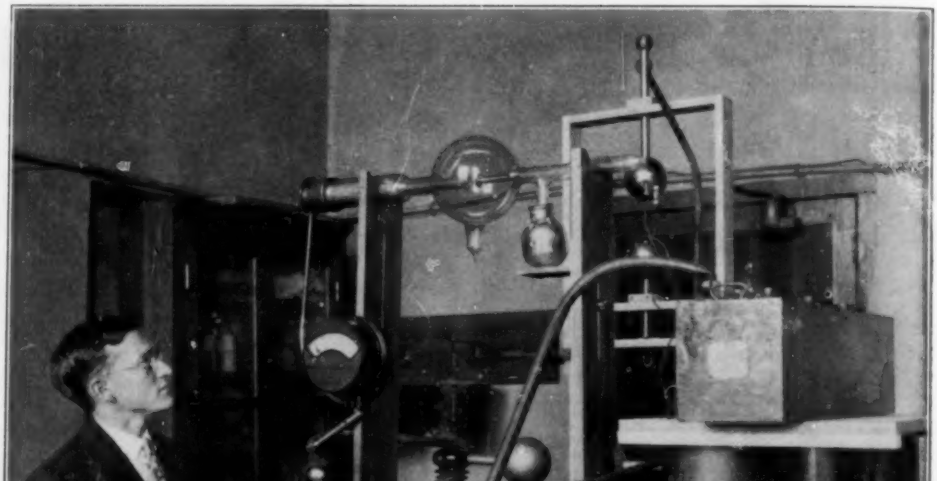
Radium is constantly disintegrating, and in so doing is bombarding electrons—infinitely small particles of matter or electricity—into space at very high velocities. The rate at which radium disintegrates is beyond human control; nothing that man can do seems to affect the rate at which the element breaks down. The cathode ray tube likewise bombards high speed electrons into space, but at a rate that can be controlled by man, and in quantities far greater than by all the radium in the world. The electrons given off by radium are of higher average velocity than those so far produced with the cathode ray tube, but otherwise the two are alike.

So much more concentrated are the rays from the tube that many startling experiments have been conducted with the new device. Crystals of the mineral calcite apparently become red hot coals when exposed for a moment to the rays, but they are glowing with cold light; ordinary salt is turned brown, and considerable time elapses before it again becomes the colorless substance it usually is; bacteria and small flies are almost instantly killed by exposure to the rays; ordinarily colorless acetylene gas is transformed into a yellow solid which can not be dissolved; and a rabbit's gray hair has been destroyed, to be replaced later by a profuse growth of longer, snow-white hair.

Cathode rays have been known to some extent for many years. At first, however, they were known only within vacuum tubes, but about thirty years age a European scientist, Lenard, succeeded in making the electrons pass through a tiny piece of extremely thin aluminum foil cemented to the glass wall of the tube. Improvements have been numerous since then, but with previous tubes the metal "windows" were much smaller and the operating voltages much lower than with the new tube.

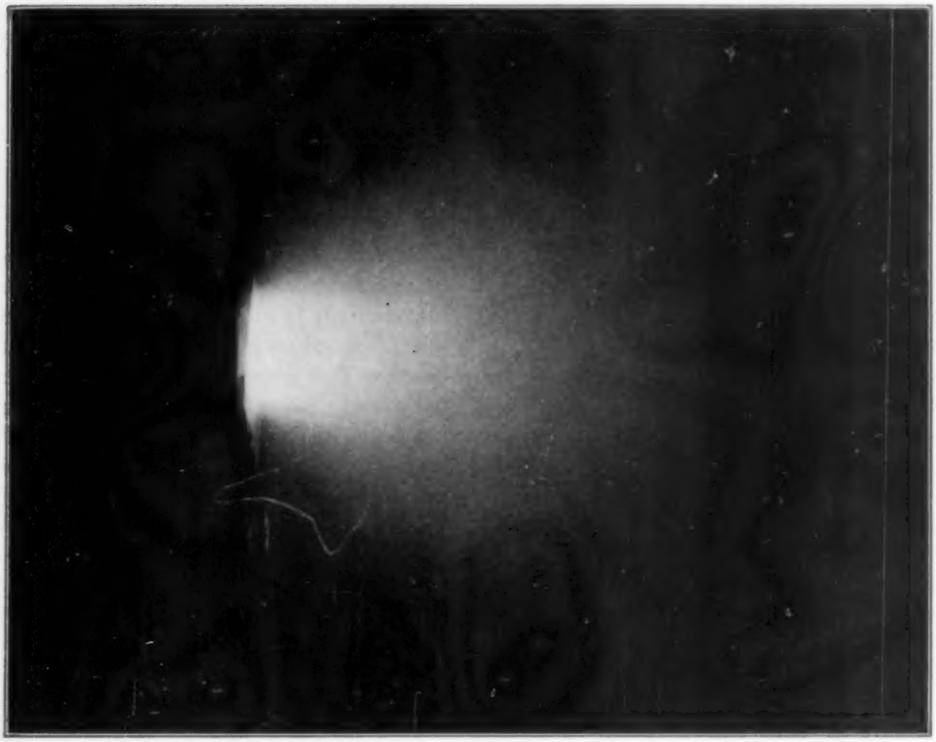
Several unusual features have been incorporated in the new tube. There is a "window" three inches in diameter, of nickel foil, the thickness of which is measured in thousandths of an inch and which is capable of withstanding a total atmospheric pressure of more than 100 pounds. A heated tungsten filament, originally used by Dr. Coolidge in the X-ray tube and now known to all as an essential part of radio tubes, furnishes the supply of electrons. The glass tube has been shielded with a copper tube so that the stream of electrons can not strike the glass and cause punctures, thereby permitting operation of the tube at voltages far higher than any previously attained, and the tube is also the first which it has been possible to seal off from an evacuating system; the tube thereby has been made as portable and as easy to use as an X-ray tube.

Electrons are released by the heated tungsten filament, or cathode, at relatively low velocity—a matter of a mile or two per second. Between the cathode and the anode—the "window" and the copper tube which serves as a shield—there is impressed upwards to 350,000 volts of direct current. This causes the electrons given off by the filament to



THE CATHODE RAY TUBE

THE HIGH POWER VACUUM TUBE AS IT APPEARS INSTALLED IN THE LABORATORY.



BALL OF PURPLISH HAZE

SHOWING THE IONIZATION OF THE AIR CAUSED BY THE ELECTRONS THAT PASS THROUGH THE NICKEL WINDOW.

speed up to an average velocity of 150,000 miles per second or more, depending upon the voltage, within the short space of about one inch between the cathode and the copper tube shield. Having attained this high velocity, the electrons coast the rest of the way through the highly evacuated tube and pass through the anode or window and into the atmosphere with but slight diminution in velocity.

The nickel window is soldered to a disk of invar, an alloy which expands the same amount as does glass when heated. The invar disk, in turn, is fused to the glass tube, thereby making the seal air tight. The thin piece of nickel itself could not withstand the atmospheric pressure of 100 pounds—the difference between the outside air and the almost perfect vacuum within the tube—so it is reinforced with a honeycomb structure of molybdenum metal, a design that affords a maximum of strength with a minimum of cross-section area.

If the tube is operated in a darkened room, a hum is heard and the window of the tube is seen to be surrounded by a ball of purplish haze, about two feet in diameter with 350,000 volts and more or less depending upon the voltage. This glow, which shows the penetration of the cathode rays in air, results from the air being ionized or broken up by the rays or electrons. The penetration of the rays depends not only upon the voltage

but upon the density of the substance they strike, so that with most solid substances the penetration is slight, and with dense metals almost negligible.

One of the most startling experiments performed with the new tube has been the production of a yellow compound when the rays are passed through acetylene gas. This compound, similar to that produced in very small amounts by radium treatment of the colorless gas, can be produced in relatively large quantities with the cathode ray tube either as a light, fluffy powder or as a varnish-like film on substances within the gas chamber, depending upon the electrical conditions. The compound has been found to be insoluble in all the many chemicals so far tried. It seems, therefore, that a use may be found for it as a protective coating for metals, to which it adheres tightly. Other substances, such as castor oil, can also be solidified by exposure to the rays.

In ascertaining the effect of the rays on living tissues, small circular areas of the ear of a gray rabbit were subjected to short exposures to the rays. Exposure of a tenth of a second caused a temporary loss of hair over that area. When the exposure on another area was increased to one second a scab was formed. When this fell away it took the hair with it, and weeks later the area became covered with a profuse growth of longer, snow-white hair. Exposure for a minute resulted in the formation of a scab on each side of the ear. A hole was left in the ear when the scabs fell away, and the edge later became fringed with white hair. In other experiments, bacteria and flies were killed almost instantly by the rays.

A crystal of calcite, a colorless and transparent mineral, glows with a bright orange light if subjected to the rays, and the glow of cold light continues for hours. The glow comes from an area very near the surface of the crystal since the rays penetrate but little into the substance. Immediately after the crystal has been rayed, numerous bluish-white sparks or scintillations can be noticed beneath the surface of the crystal; these are electrical explosions, the result of the bombardment of the atoms in the crystal by the high-speed electrons.

Granite, a mixture of several minerals, glows with several brilliant colors, some of the colors fading away immediately and others remaining for some time. Numerous other substances can be made to change in color, some permanently and others for a short time.

The commercial possibilities of the tube, still a laboratory development, are unknown but it is expected that the tube will be invaluable in scientific investigations regarding electronic phenomena.

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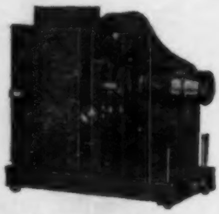

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